

**THE KEY ISSUES FACING
THE ELECTRICITY SYSTEMS OF
DEVELOPING COUNTRIES**

**PRESENTED BEFORE
THE
CO-OPERATIVE PROGRAMME ON ENERGY AND DEVELOPMENT**

**DRAFT MARCH 1990
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This is a first draft based on information received from Members of the COPED Network. This draft will be changed in the light of
received from the Network. The meeting is to be held in Grenoble in April 1990. It is therefore most important that this
should not be circulated.

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CHAPTER 1 INTRODUCTION

Energy emerged as a global issue in the 1970's. The rapid escalation of oil prices, following the decision of Arab oil-producing countries to embargo oil supply to countries politically supportive of Israel, drew the attention of oil-importing countries to the serious economic problems they would face whenever there is a sudden energy shortage or a substantial increase in energy prices.

Domestic policies to foster indigenous energy supplies and to reduce energy consumption were adopted in most countries. These policies were intended to reduce dependence on energy imports, especially oil, and indeed in many countries they succeeded. But there were unanticipated consequences: world oil consumption stagnated and several new oil exporters sprang up. Oil prices fell sharply from the very high levels they achieved in 1980 to current levels which are close in real terms to 1973 prices. The widespread conviction that fossil fuels, particularly oil, would remain scarce and expensive for a considerable time has now evaporated. Indeed the current perception is that the fossil fuel resource base can sustain world energy consumption for the foreseeable future at reasonable prices.

While the problems of oil have declined in importance, the environmental issue has emerged and more recently still global warming has been identified as the major long term challenge facing industrial economies. This shift has resulted from the strong public opposition to nuclear power and the recognition of the large contribution that fossil fuelled power plants make to CO₂ emissions, the single most important global warming gas. The key energy questions no longer focus on oil but on electricity generation and consumption.

Strict regulations are emerging to cope with the environmental problems produced by electricity. These in turn lead to substantial increases in the investment and running costs of utilities. Electricity

prices, which had escalated after the oil crisis are likely to remain under pressure and to rise even further in the future. There will also be a massive process of technological change to reduce the environmental impacts of the electricity system to levels acceptable for society. This new situation introduces large uncertainties about the future of electricity, both from the supply and demand sides, that necessitate a comprehensive review.

Electricity remains a fundamental component of any strategy for economic development. Modernisation can hardly be imagined without the spread of electricity consumption. While there is some empirical evidence that electricity is not a sufficient condition for economic development, there are few cases where it is not a necessary condition. However, electricity supply is capital intensive and drains such a large share of scarce financial and technological resources that it produces major macro-economic impacts. Policies in this sector have multiple dimensions which need to be carefully assessed before decisions can be made. This is particularly important for developing countries where electricity is currently available only to a part of the population but where there is strong political pressure to make it available universally.

The share of electricity in the energy balance is expected to increase in both industrial and developing countries, although for different reasons. In industrial countries, not only is electricity increasingly a preferred energy source, its share of the energy balance could possibly rise without substantial increases in electricity consumption as fossil fuel use falls. In developing countries, the situation is quite different; population growth, urbanisation and industrialisation mean that electricity consumption will rise absolutely, as well as relative to other energy sources, for many years yet.

The need for electricity in industrial development is widely observed in both the North and the South. But electricity also appears to play a catalytic role in modernising traditional sectors. A large proportion of developing countries' populations is not able to satisfy its basic needs, because the traditional sectors of their economies both in rural and urban

areas still use archaic technologies for producing goods and services. In these sectors, productivity is very low. It is likely to remain so unless technological changes can be introduced, as there are limited endogenous mechanisms to improve productivity. Moreover, these traditional sectors maintain a symbiotic relationship with the modern sectors of the economy and they do not disappear as industrialisation proceeds.

Policies that can increase productivity in traditional sectors of developing countries' economies are urgently required. Electricity may well form a significant component of these policies, but many developing countries face such huge financial problems that they are unlikely to be able to develop their electricity systems sufficiently to meet the needs of industry or the wider needs of development. In these circumstances, a reassessment of the key issues facing the electricity systems of developing countries is likely to be a priority.

This report offers policy-makers both in industrial and developing countries a fresh look to these issues. It is unusual in taking a "southern" perspective on these problems and by taking a view that is independent of both government and utilities. The report is produced by independent energy research institutes in Asia, Africa, Latin-America and Europe. The Group has been working together for almost ten years, and is funded by the Commission of the European Communities.

1.1 Methodology

The framework for the research was agreed at a joint meeting in Cuernavaca (Mexico) in April 1989. Each of the participating institutes from developing countries studied the electricity system of their own country and provided an overview of the wider situation of the electricity sector in their sub-region. Institutes from Europe contributed a review of World Bank energy lending policies and an assessment of the major issues in the electricity systems of industrial countries that may have a bearing in the South.

This combination of country and regional studies was a necessary compromise between the desire to be comprehensive and the finite resources available to carry out the project. Its main aim was to produce a 'southern' perspective on the key issues facing the electricity systems of developing countries; its main weakness is that the process of aggregation tends to discount the problems experienced by individual countries, particularly those that are small and isolated (especially islands). Hopefully the knowledge accumulated by the institutes over many years of research on energy issues in developing countries has avoided the possibility of major points being overlooked.

The study starts from the premise that the electricity sector has experienced sharp changes in recent years and that the policies of the past are unlikely to provide sufficiently robust solutions to the challenges of the 1990's. This view is reflected by the recent publications of the World Bank. The Bank has been involved in the development of the power sector of most developing countries and its role as the largest single source of finance to the power sector gives it a unique vantage point both to view the changes that are taking place and to offer their vision of the world in the search for solutions. We therefore start our study with a review of current thinking at the Bank (Chapter 2).

The need for fundamental changes in the electricity systems of developing countries is clearly precipitated by the financial crisis of both utilities and treasuries of many developing countries. This reduces substantially the scope for new projects in the electricity sector. But the search for solutions is strongly influenced by the recent experience of some industrial countries which are introducing radical changes in the institutional arrangements of their electricity supply systems. Our study therefore examines the experience of industrial countries to see what lessons can be learned for the potential effects of such policies in developing countries (Chapter 3).

Our main evidence is gathered from country studies which provide a comprehensive diagnosis of the situation and outlook of the electricity systems of a few key countries in the main developing regions of the world

(see annexes). These, supported by less ambitious regional studies, are reported in Chapters 4, 5 and 6. These studies permitted the identification of the key problems and issues facing the electricity systems of developing countries (Chapter 7).

Finally (Chapter 8), we have attempted to contrast the problems and issues that derive from a Southern perspective with those from the international financial system, the World Bank and other donors. While there is a broad consensus between most observers on the nature of the problems, there remain substantial differences in policies. These centre on differences in the objectives set for the power sector, the extent that the power sector can be isolated from the rest of the economy and the precise role of the private sector. We have tried to analyse and describe the nature of these differing perceptions and clarify the nature and content of the various policy prescriptions proposed.

1.2 The Sample

The term "Developing Countries" is a loose category to apply to as diverse a group as our sample of countries, and clearly no single set of policies can suit their range of economic, social, political, geographical and historical situations. Nevertheless, developing countries do have several common features and they face many similar problems. Absolute poverty and the low productivity of a large share of their population are central features of developing countries' societies that influence and constrain the growth of their economies in general and of their electricity systems in particular. Conversely, decisions taken in the electricity sector determine and limit to a large extent the opportunities to increase productivity and wealth of developing countries' populations both because of the capital they use, and through the level of service they supply. But we would argue that a similar general approach can be taken by policy makers to solve problems of developing countries' electricity systems, although detailed policies and priorities will necessarily vary from country to country.

For the purpose of our study, we took into account historical and geographical similarities to divide the developing world in three major main regions: Africa, Asia, and Latin-America. The Middle East was excluded from the current analysis because little analysis has yet been carried out by COPED members on this area. Each of the three main regions were further divided into sub-regions to offer a more homogeneous picture of their development and energy situations. Africa was divided in 6 sub-regions (North Africa; Sahel-West; Sahel-East; Atlantic Coast; Nigeria; Center-East and SADDG); Asia in 5 (North-East, South-East, Indochina, China and South) and Latin-America in 5 (the Southern-Cone, Andean Pact, Central-America, Brazil and Mexico).

Our sample covers 11 developing countries from Asia (China, India and Thailand), Africa (Ivory Coast, Senegal, Mali, Algeria and Zaire), and Latin-America (Argentina, Brazil and Mexico). In 1987 they accounted for 60.3% of developing countries' population and 49.4% of developing countries' GDP. Their share in developing countries' modern energy consumption was 63.7% while their share in developing countries' electricity production was 56.8%. It seems reasonable to assume that the sample therefore offers a useful picture of developing countries' electricity systems.(1)

As far as economic development is concerned the countries of our sample face very different situations. Some countries like Argentina, Brazil, and Korea are part of the middle income group of developing countries and have relatively sophisticated industrial sectors that can supply their domestic markets with most consumers' goods and a substantial portion of capital goods. China and India also have large economies which have a wide range of well established industrial sectors which can supply a significant proportion of their capital goods need, but overall have lower per capita income.

Thailand and Algeria exhibit yet another set of characteristics. They are also part of the middle income group and have already developed a dynamic industrial sector that can provide a significant share of their domestic consumers' goods. Ivory Coast and Senegal, although again part of

the middle income countries, still are economies largely based on primary sector activities. Finally, Mali and Zaire are part of the lowest income group and their economies are also based on primary production.

Obviously, substantial differences of industrialisation and GDP per capita results in considerable variation in the per capita levels of modern energy consumption and electricity production. Figures for Latin-American countries and Algeria are above developing countries' averages but still considerably lower than OECD's averages; China's and Thailand's patterns are close to the average for developing countries' but India and the African countries figures are much lower. These disparities are an indication of quite different development situations of their electricity supply industry.

The Asian and Latin-American samples both offer a substantial picture of their region. China, India, and Thailand represent 73.9% of the region's population; 59.6% of the GDP; 75% of modern energy consumption; and 67.5% of electricity production of that region. Brazil, Mexico, and Argentina embody 61.6% of the population; 70.4% of the GDP; 70.3% of modern energy consumption; and 66.9% of electricity production of Latin-America.

The African sample is less representative of its region but nevertheless offers clear insights into the general situation of most countries of the region. The African countries together represent 12.9% of the continent's population; 15.5% of the GDP; 8.9% of modern energy consumption and 6.4% of the electricity production.

1.3 Relevance to Industrialised Countries

This study has been financed by the Commission of the European Communities. It is therefore reasonable to ask what interests industrialised countries may have in its results. First, the study provides a well-informed Southern view that is independent of the political biases inherent in all government statements about controversial issues. Second, the subject matter is inherently important for industrialised

countries. This works at a number of levels: developing country electricity systems continue to grow and to use higher proportions of fossil fuel than in the past. This has obvious implications for world fuel price levels and global environmental impacts. At another level, developing country electricity systems absorb huge quantities of capital and make significant demands on the world's banking and financial system. Looked at from a related angle, developing countries constitute a large and increasingly important market for the world's power plant manufacturers, predominantly situated in industrialised countries. A study of this sort therefore impinges on the interests of industrialised country energy (and environment) policies in a number of key areas.

FOOTNOTES

- (1) Problems faced by small developing countries, particularly islands, are not analysed in this report.

CHAPTER 2 NEW ENVIRONMENT, NEW POLICIES

2.1 The Context of Electricity Systems in Industrialised Countries

Something of a consensus is emerging which suggests that the 1970's represented a turning point in the power systems of the industrialised countries. The 1950's, 1960's and even to a degree the 1970's were a kind of golden age. A virtuous circle of cost cutting innovation, increasing demand levels, economies of scale and generally low interest rates allowed the industry to grow rapidly at falling real cost. Electricity, whether privately or publicly owned, existed in a world of little political prominence or controversy. The first changes occurred in the 1970's, when rising fossil fuel prices led, for the first time in three decades, to an increasing real price of electricity. The consequences of rising prices and industrial recession for electricity demand were not quickly foreseen, and the legacy was a set of electricity demand forecasts that were in general serious overestimates of actual demand. This in turn led to plant surpluses emerging in the 1980's, with further pressures on price because of the need to service a larger debt with a smaller than expected output.

While the 1980's have seen an abatement in the level of fossil fuel prices, the electricity supply industry (ESI) has hit further serious pressures. The first of these was an upward shift in the level of real interest rates. In an industry as capital-intensive as electricity supply, this intensified the burden of debt from earlier over-investment: but as the perception of a higher-interest environment became established in utility planning, it also led to quite new incentives as far as investment behaviour was concerned. In the first place, it encouraged a lower volume of total investment in new plant, and encouraged a much less capital-intensive mix of investment, including the life extension of older plant.

Meanwhile, other problems and opportunities emerged in the area of supply side technology. First some of the large-scale technologies which had promised so much in the earlier years became less attractive.

Prominent among these were nuclear power, where public resistance and escalating costs made expansion increasingly problematic, and super-critical fossil fuel generation, which was so plagued by technical problems that it has all but been abandoned as a major power source. Economies of scale were becoming exhausted, and the first signs of possible diseconomies to scale became apparent; meanwhile, there was little scope for further interconnexions within national boundaries. Meanwhile, technological development tended to favour technologies which are less capital intensive and, at present, more economic at smaller sizes, particularly gas turbines in combined cycle. (Such technological tendencies were of course reinforced by higher interest rates.)

In the 1970's, a cluster of environmental issues had started to emerge and began to become important in policy terms in the early 1980's. Initially, these concerned mainly local issues like the siting of large-scale facilities (particularly nuclear power and hydro electric schemes), but increasingly, regional issues became prominent, and then latterly global questions. Airborne pollution has been particularly important, first in the form of concerns about acid deposition, and then more recently in the rapidly escalating interest in global warming. These concerns have increasingly been translating into more stringent environmental standards, with further consequential pressures on costs.

Rising electricity prices - sustained by problems in energy supply technology environmental issues, once fossil prices fell in the 1980's - gave strong incentives towards limiting electricity use. Technological change, especially in the area of micro-electronics, with its capacity for close monitoring and control, reinforced the market incentives towards greater efficiency in electricity use.

Pressures on costs and prices were also largely responsible, in the 1980's, for an increasing level of discontent with utilities on the part of their consumers. While some of this was articulated by household consumers, much the greatest pressure came from industrial consumers, who grew increasingly restive, as captives of utility monopolies, at the need to pay ever higher prices.

Finally, but far from least important, there has emerged from around 1980 a new form of political philosophy which can be loosely described as neo-liberalism. This had its first and perhaps most radical impact on the English-speaking world, but its influence has been considerable throughout the industrialised countries. In terms of its impact on the electricity system, it offered a strong critique of the impacts of public ownership (where that existed). The two major aspects of this critique concerned on the one hand, the tendency of governments to interfere in the management of utility companies, and on the other, that the ill-defined nature of a public sector's objectives allows management undue freedom to pursue whatever it likes with little genuine accountability. In addition, there has been a critique, especially in the USA where most electricity ownership is private, of public regulation ('regulatory failure'), which partly stems from the same neo-liberal world view.

The combination of these various new developments left some utilities weakened, and offered scope for new actors, particularly industrial electricity consumers, to start playing a more influential part in decision making. Utility weaknesses stemmed from several factors; first was their own planning failures, exemplified by their overblown forecasts and excess plant capacity, and which in turn led, in some countries, to increasing financial weakness. Secondly, there was the focus of much environmental criticism on the utility industry as a prime source of the environmental ills of which public consciousness was becoming increasingly aware. Finally, in an increasingly neo-liberal political climate, monopoly industries, state-owned or state-regulated, came in for substantial criticism on partly ideological grounds. The traditional financial and political strength of some utilities was thereby seriously weakened; so that when reforms of structure, ownership and regulation were proposed from the late 1970's onwards, utilities in the affected countries were not in a strong position to mount effective opposition. This meant that some governments were able to act decisively in effecting reforms.

2.2 Challenges Facing Developing Countries

Until the oil crisis of the 1970's, trends in the ESIs of most developing countries were similar in many ways to those of industrial countries. But the situation they faced was very different. The

electricity supply industries were growing steadily, and satisfying a rapidly growing demand for power at prices that were falling in real terms. Despite low levels of performance relative to power plant in industrialised countries, they were also experiencing improvements in productivity which reduced their costs. These improvements in productivity largely resulted from the introduction of new vintages of larger scale technologies that had been developed for industrial countries and were progressively introduced into developing countries, although with some delay.

As in the North, the underlying situation facing electricity systems of developing countries changed in the 1970's. But these changes were hardly noticed by consumers, or indeed, even by utilities. Costs escalated but electricity prices were generally not allowed to increase in real terms (see chapters 4,5, and 6 of this report). Many governments in developing countries, and in some industrial countries as well, chose to protect consumers from the impact of rising electricity prices for macro-economic reasons.

Many opportunities existed to reduce the pressure on costs by improving technological performance. Thermal efficiency in developing countries was still low; interconnexions between regional grids were far from complete; the scale of power plants were well below the levels in industrial countries; etc. These improvements could, in principle, be achieved quickly as electricity consumption was still rising rapidly as a result of population growth and urbanisation. But the forces that were causing fuel and investment costs to rise in the North were also operating in the South and reducing the possibilities of technological improvements. In the circumstances, either electricity prices had to be increased to cover cost, or subsidies had to be provided.

Unfortunately, prices were not increased nor were subsidies provided to cover the increasing costs of utilities. Despite reduced cash flow, utilities from developing countries had to maintain high levels of investment as they were committed to supplying electricity to meet a rapidly increasing demand. They were keen to borrow heavily to finance their investments and thereby increase the electricity supply infrastructure. This coincided with a massive increase in the supply of short term, floating rate, commercial bank loans.

The subsequent changes in world financial markets and their dominating effects on power sector development are discussed in the following section. But it is clear that the most pressing challenges facing developing country utilities in the 1990's are to recover their ability to invest not only to meet the increased needs of a rapidly growing population, but also to improve technical performance. This is a rather substantial undertaking that obviously cannot be achieved without the implementation of suitable domestic policies. But the scope for domestic policies and, more important, the likelihood of their success, will also largely depend on substantial changes in policies in industrial countries, particularly those controlling the flows of capital.

Developing countries do, however, have some room for manoeuvre in influencing the behaviour of industrial countries. In particular, they can adjust their policies to attract foreign capital and technological expertise to the ESI, although they will remain strongly dependent on industrial countries as far as financing is concerned.

The bargaining strength of developing countries derives from two sources. First, the share of developing countries in world power plant purchases has been increasing rapidly. Contrasting with industrial countries where electricity consumption is growing slowly, developing countries' electricity consumption is still growing relatively fast for reasons already pointed out; between 1971 and 1986, electricity generation in developing countries increased annually by 8.7% while increasing only 3.5% in industrial countries. In the 1980's, there has been a slowing down in electricity generation growth in both developing (7.1%) and industrial (2.2%) countries, and developing countries' growth therefore remains over three times higher than industrial countries'.

These trends rapidly increased the share of developing countries in world electricity generation from 9.9% in 1971 to 14.5% in 1980 and 18.0% in 1986. More important, the shares of both industrial and developing countries in the incremental generation of electricity has changed dramatically in recent years; developing countries already account for 50% of all purchases of power plant and this is likely to increase steadily in the future. Therefore, the power plant market will increasingly be a developing countries' market.

The second reason for developing countries' bargaining strength is that they still have large resources of low cost conventional energy that remain underutilised. For instance, only 16%, 13% and 4% of the hydropotential of Asia, Latin-America and Africa respectively are currently exploited; large fossil fuel resources remain underexploited, especially natural gas. It is worth remarking that in the 1980's the share of developing countries in incremental hydro-power generation was already twice that of industrial countries. These figures suggest that developing countries can attract electricity-intensive industries from industrial countries if they wish to provide electricity efficiently from their large non-tradeable energy resources.

2.3 Finance and Power Sector Development

Developing countries face a buyers' market for power plant but a sellers' market for the related finance.

The fall in demand for new power plant in their traditional home markets over many years, has forced power plant manufacturers in the North to restructure their industry, form strategic alliances with other major producers and seek out new markets in a desperate attempt to maintain their production capacity. Among these new markets, developing countries represent one of the few areas of the world where the need for power plant has continued to grow. It is a highly competitive market and developing countries have the potential for dictating advantageous terms.

However, the lack of finance for such investments has always formed a major constraint to such sales. To some extent, the equipment supplier and the equipment buyer have had a coincidence of interest in persuading banks and aid agencies to fund their particular project.

Government involvement has usually been necessary either directly or indirectly to overcome the special financing problems in developing countries. This was not only because power supplies form a "natural monopoly", but also because most power generation investments are large (relative to other investments within the economy), they incur foreign exchange costs but sell their product exclusively in local currency

(thereby producing a major fiscal and macro-economic adjustment even in the best of times) and because each investment takes many years from start to finish. Unlike the situation in the oil and gas sector, where much of the investment is financed from within the cash flow of transnational corporations (73% of oil exploration costs are financed in this way), power projects have had to be financed from within the utility, from aid, or from commercial sources (often against government guarantees).

The social and developmental targets set for the power sector by governments (often combined with weak utility management) have meant that power utilities in developing countries have increasingly been unable to meet a target of financing 20-30% of their investment from revenues.¹ In a number of countries, the shortage of local finance has been historically a greater constraint to power sector development than foreign exchange. Typically some 50% of power generation project costs are in local currency, though countries such as Mexico have achieved a local cost content as high as 80%.²

For certain periods of the last 20 years, much of the competition for a share of developing country power plant sales has taken the form of interest rate competition, with donor agencies and commercial banks out-bidding each other by developing schemes to soften the terms of loans. By the mid 1980's the watch-dog of bilateral aid (the Development Assistance Committee of the OECD) was drawing attention to these schemes, not because they lead to lower rates of interest to recipients, but because they were said to be subverting the pattern of aid to the exclusive service of donors' commercial interests. The main vehicle for such competition was the use of Official Development Assistance ("oda aid") in combination with export and other credits to form "mixed credits". In order to combat such tendencies, the OECD administers a scheme whereby the donors agree not to offer terms that go below a previously agreed "consensus rate" for each recipient country.

At the same time as this concern for mixed credits, the OECD also reported a sharp increase in the volume of tied aid credit notifications under their Export Credit arrangements. In the early 1980's, Japan's aid was the least tied (17%), and with Austria (77%), Canada (59%), France 46%, and the UK (41%) being the most tied.

But against this background of tying and mixed credits, the last 20 years have also seen dramatic shifts in the magnitude and form of financial flows to developing countries, both between countries and over time. The first shift has been away from Government-to-Government aid finance in the 1960's towards a considerable growth in funds from private banks and export credits. This is reflected in the statistics for total financial flows from the OECD countries to the South: in 1970, private financial flows accounted for only 44% of the total net financial flows to developing countries, but by 1975 private flows had grown to nearly 60% of total net flows. Since then the share has fallen away again and by 1987 was less than 30% of the total net flow from the OECD.

Together with the shift from public to private finance there have also been major changes in the size of the net flows. Total net flows nearly doubled in real terms in the five years 1970 to 1975 from \$50 billion in 1970 to \$94 billion in 1975 (in constant 1987 prices and exchange rates). In the second half of the 1970's the net financial flows to all sectors grew more slowly and by 1980 had reached \$99 billion in real (1987) terms. The increases in credit in the 1970's arose in large part from the needs of the Northern financial institutions to re-cycle oil surpluses. With hindsight it would appear that both lending and borrowing institutions share the blame for incurring such very high levels of debt. The inability of countries to repay the debt service reversed the earlier trend and the net flow of resources fell in real terms to nearly \$66 billion in 1987. This fall was most severe for private flows which fell to less than 30% of the 1987 total net flow. The near cessation of new export credits even resulted in a net resource flow from the poor countries to the rich.³

The sectoral breakdown of debt is not widely available. But by the end of 1975 the total Third World public debt attributed to the power sector was \$57.7 billion. Of this 35% was "export related" (i.e buyer and supplier credits), 33% was to financial institutions for floating rate private commercial loans, and 20% to multilateral concessional aid. There was however considerable variation within these aggregates. As might be expected, the low income countries obtained over 80% of their overseas finance for the power sector from multilateral (54%) and Bilateral sources (29%), while middle income oil importing countries obtained nearly 70% from commercial banks and export credits.

In the current period, data for Latin America show that of their total debt in 1987 of \$423 billion, some 18.4% (\$78 billion) was attributed to the energy sector as a whole, and of the energy sector debt some 60% was attributed to the power sector. Analysis of this Latin American energy debt by creditor shows that of \$78 billion outstanding in 1987 over 70% was with private banks, nearly 10% each to the IDB and the World Bank, with 5.4% to bilateral aid agencies and 4.3% to suppliers. In Thailand during the period 1980-1986, 91% of all ESI borrowing was from foreign sources (\$2.7 billion) and of this 31.3% came from the World Bank and the Asian Development Bank, 23.4% for Commercial bank and 18.7% from supplier/buyer credits.

Although it has not been possible to obtain a sectoral breakdown of energy related debt for other regions, published statistics show that for sub-Saharan Africa just under 40% of the debt is to private creditors and that of this private debt one third is guaranteed by creditor governments. Debt service payments now equal 47% of Africa's export earnings and cannot therefore be met.

In the very recent past, total net flows have eased very slightly as private flows have begun to increase in 1987 and 1988. But this rise is largely accounted for by flows to the NICs of Asia (Thailand, South Korea, Malaysia and Singapore). Bank lending rose in Asia but fell in Africa and Latin America, producing an overall fall in bank lending in 1988.

The situation would have been far worse had it not been for another trend: the growth in financial flows from Japan. This has been a major feature of Third World finance in the 1980's and current plans suggest that it is likely to remain so well into the 1990's. Total net financial flows from Japan increased from an average of \$7.9 billion in 1977/79 to over \$21 billion in 1988 - a rise of nearly 40% in real terms (from \$13.6 billion in 1977/79 to \$18.9 billion in terms of 1977 prices and exchange rates). This compares with a fall in net resource flows in real terms for countries such as the US and UK over the same period (for the US from \$27.3 billion to \$16.9 billion and for the UK from \$22.3 billion to \$2.6 billion).

However, Japanese financial flows are significantly different from the flows of other countries in that a far larger part is made up of private capital (largely commercial funds at market rates). Just over a quarter of Japanese financial flows in 1977/9 were in the form of official development

assistance ("oda"⁴). By 1988, oda had risen to just over 40% of their total net financial flows, but this was still well below the average for all OECD countries of over 60%. Even so, the Japanese oda provided nearly 20% of all DAC oda and was the second largest bilateral programme in 1988 (at \$9 billion, second only to the US at \$10 billion). The Member countries of the EC provided \$24 billion of oda during the same period.

Of particular importance is that the Japanese devote a much higher proportion of their funds to infrastructure projects than other donors and that within this, allocation to the energy sector (largely power) is particularly dominant. Thus the Japanese committed a larger proportion (18.1% in 1987) of their oda to the energy sector than any other bilateral donor (the comparable figure for the DAC as a whole was 7.9%). The only organisation to commit a greater proportion of its aid funding to energy was the World Bank at 22%. But given the scale of Japanese oda the amounts they committed to the energy sector in 1987 were \$1.33 billion. This is over two and a half times the amount of the next largest bilateral donor to the energy sector (Italy at \$496m). For comparison, the amount committed to the power sector by the World Bank in 1987 was \$2.69 billion, and the amount of oda committed to the energy sector by all the member countries of the EC is almost exactly the same as the Japanese at \$1.32.⁵ But it must be stressed that these flows are for oda only. Given the high proportion of private finance in Japan's total financial flows, it can be assumed that they invested even larger private funds to the power sector.

Japan's aid is concentrated in Asia with Indonesia being the largest recipient for many years (with 22.9% in 1970/71 and 11.9% in 1987/8). In recent years, China has taken second place with 6.6% of the total and a larger share has been allocated to Africa (Egypt in 13th place with 1.6%) and Latin America (with Brazil in 15th place with 0.9%).

2.4 Financial Requirements of Developing Countries in the Power Sector

Although these financial flows are substantial they have to be put in the context of need. It has been estimated that the annual investment required by the power sector in developing countries lies between US\$60 billion and US\$100 billion.⁶ Of this, at least \$25 billion is thought to represent the requirement for imported equipment. The same source suggests

that total bilateral and multilateral aid to the power sector is thought to be less than \$10 billion annually (this presumably includes non-OECD sources: commitments to the energy sector in 1987 were approximately \$3.132 billion from bilateral sources with an additional \$2.6 billion specifically for the power sector from the World Bank; other aid sources would include the EC and the Regional Development Banks). The \$15 billion short-fall compares with a total net flow from all export credit and private sources of \$36 billion for all economic activities of all developing countries.

Such an imbalance between the foreign exchange need in the power sector and the likely amounts of flow from abroad implies one or more of the following strategies:

1. a reduction in investment in the power sector,
2. an increase in the proportion of aid being allocated to the power sector,
3. an increase in domestic finance for power sector development,
4. an increase in private foreign investment in the power sector.

The first of these options falls largely outside the scope of this paper. A fall in investment has already taken place because of the debt crisis (Chapters 4, 5, and 6). The fall is substantial and will no doubt form a major constraint to achieving economic growth in the modern sectors of developing countries. There is evidence of considerable shortage of electrical energy in some countries (China, for instance, is reported to have as much as one third of its industrial plant idle at any one time due to power shortages).

The second option, more aid to the power sector, appears unlikely in the near future. Although the strong downward trend in aid allocations has now been halted at least for the time being, there seems little evidence that the international community is willing to substantially increase aid allocation, or more fundamentally, tackle the debt crisis. Most commentators predict a continuation of interest rates at historically unprecedented levels and a hardening of import restriction to Northern markets (for instance through the common tariffs surrounding the single European Market).

If the volume of aid is unlikely to change, the terms and conditions of aid flows may well change in ways that affect the power sector. First there is the question of tying aid to goods and services supplied by the donor country's industry. There has been a general move away from the tying of aid, but there is still wide variation: nearly half (46.5%) of Japanese oda is untied compared to less than 10% of Italian aid.

It is still unclear whether the single European Market in 1992 will allow competitive tendering for all aid originating from Members of the Community. The legality of tying aid to each member's suppliers is currently being challenged by the Irish in the European Court. But recent amalgamations, take-overs and alliances between major equipment suppliers somewhat undermines the concept of national suppliers. But complete untying within the community might be expected to lower the cost of power equipment to developing countries, although such untying might equally reduce the amount of aid member countries are prepared to provide.

The quality of aid is also likely to be affected by the conditions imposed on aid flows by the donors. Much of the current aid "conditionality" is aimed at restructuring developing country economies and introducing "more realistic" pricing systems. In the power sector, this has meant a clustering of bilateral aid terms around the conditions imposed by the World Bank. These usually require some movement towards cost covering average tariff levels, improved management and some targets for self-financing. Some of these conditions are welcomed by utilities as they strengthen their position against the interference by governments, with their wider economic and developmental objectives. However, such conditions tend to assume that the problems of the utility can be isolated from more widespread problems of the economy (staffing levels, salary and other input pricing policies, etc.).

While there is much agreement among donors on the types of conditions that they wish to attach to aid to the power sector, there is still considerable variation on the question of on-lending. Official Development Assistance is usually provided from one government to another. The receiving government then on-lends the funds to the implementing agency. Even where the aid is initially in the form of a grant, it is regarded by many donors to be good practice for the funds to be on-lent to the utility

on commercial terms in local currency. However, where donors do not do this, they achieve a considerable commercial advantage (because their funds are clearly more attractive to the utility as being at best a grant and at worst additions to their equity on which they pay little or no dividend). It does, however, have the harmful effect of making funds for new capital equipment far cheaper than funds to meet recurrent expenditure for maintenance, training and plant operation.

The main uncertainty in future about the conditions attached to aid centres on environmental questions. Donor governments have been concerned for many years about minimising the environmental damage that may be caused by activities with which they are associated. But it is likely in future that they will focus even greater attention on activities that reduce (or at least reduce the rate of growth in) greenhouse gases and other emissions from the power sector. This is a fundamentally different concern to that of adding emission control technology to power plant. No clear picture has emerged as to how donor governments will introduce these ideas into the conditions attached to power sector development (though they have clearly already backed away from large hydro schemes largely on environmental grounds). Nor is it yet clear whether they will be willing to allocate additional funds to these environment conserving activities (there is a strong argument that they should, because in principle every dollar spent in a developing country can have a far greater effect on reducing global emissions in the inefficient plant of the Third World than in the relative efficient power plant in their own countries - even though the absolute level of industrial emissions of CO₂ from OECD countries is nearly twice that from developing countries).

Most developing countries have made efforts on the third option: to increase the flow of domestic resources into the power sector. So far, this has been tackled in two main ways: improving the financial, managerial and technical efficiency of the existing system; and second, by encouraging generation by large consumers of power.

Attempts are being made to increase the profitability of power utilities by raising average tariff income, improving financial management (billing etc), and by running the existing capital stock more efficiently (by increasing plant availability and reducing system losses to obtain more power sales from the existing plant and fuel).

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It has been observed that the financial performance of power utilities deteriorated during the first part of the 1980's. The decline is partly the result of lower than forecast sales of electricity (resulting from unpredicted/unpredictable recession), and attempts by governments to either extract revenue from utility sales or to restrain tariff increases for counter-inflationary or political reasons. There is no evidence yet whether this deteriorating trend has been halted in general, but examples from specific countries suggest that it has (though with possibly harmful effects on power sales and the costs associated with power shortages).

The second conventional approach to attracting local finance to the power sector has been the explicit or implicit policy to allow large users to generate their own power (even where these are state owned companies). In Indonesia, some 50% of all power is generated in this way. In China, the acute shortage of power has forced the Government to allow low tiers of government at the Regional, Provincial, city and firm level to invest in power plant. Such policies are perhaps inevitable and will reduce the cost to the economy of industrial power shortages, but they will further undermine the profitability of the existing utilities (by creaming off the most profitable, high load centres) and may well lead to the mis-allocation of investment resources. In particular, auto-generation policies are likely to favour industry rather than agriculture, the inefficient use of premium fuels by small scale industrial and domestic users, and the greater use of smaller scale plant.

Attempts to attract local private capital and yet avoid the "costs" associated with auto-generation focus on efforts to develop local capital markets that can channel domestic savings into efficient scale power systems. According to Churchill and Saunders at the World Bank, "The capital markets of most developing countries are more under developed than necessary". They advocate government encouragement of such markets by offering investors terms that are similar to those that have to be offered to encourage foreign private investment, including the ability to convert dividends into foreign exchange.

Certainly it might be expected that given the shortage of power for industrial production in a number of countries, power projects should show high economic returns to investment. Donor evaluations suggest that this

is in fact the case although the World Bank reports a decline in the financial rate of return on capital invested as estimated at the completion of construction (a real rate of 6% in 1980-85 relative to 9.2% in the period 1966-1973). Such declines in financial return (rather than economic returns) are due to factors similar to those mentioned previously in relation to utility viability. But the financial return on World Bank projects may not be a reliable indicator for all power projects. The World Bank is in principle a lender of last resort and it has tended direct its funds away from the large discrete power investments as these are more easily funded by private and bilateral aid sources.

It is the fourth option, of attracting a larger volume of private foreign investment to the power sector, that is seen to be both unavoidable and to offer the greatest hope for meeting at least a portion of growing power needs. Part of the optimism or even reluctant acceptance of this strategy must lie in part from the fact that in this area the developing countries have their strongest ally: the power equipment manufacturers in the North. Power equipment manufacturers rely for a large part of their sales from Third World markets, and without the necessary finance these sales will not be forthcoming. But even in the 1980's a number of manufacturers took the view that they would concentrate their efforts on the North American market, and that the Third World was not a market they would bother with.

In the 1990's the coincidence of interest between equipment suppliers and utilities is likely to hinge on the strength of demand from the more traditional and northern markets. There is still optimism that the US market is reviving, that privatisation in Europe will stimulate investment in new generating equipment (even if it is at smaller scales and with emphasis on combined cycle and gas turbine markets), and that Eastern Europe will provide an expanding market. Furthermore, the attitudes of suppliers will vary widely between countries and between types of equipment. In particular, China must still remain a major target for most suppliers of large power equipment given its huge need and relative lack of international debt, despite decisions to source much of the expansion locally and to re-consider many overseas negotiations. Suppliers to African countries, particularly in the diesel sector, are unlikely to be able to drum up similar sales and financial support.

Many of the schemes required to attract foreign capital will be similar to those required to attract local capital: linking generation projects to particular heavy users of power, and the negotiation of long term contracts covering sales of power and the purchase of fuels. But in addition private foreign investment will require mechanisms to guarantee the conversion of local cost revenues into hard currency and their repatriation overseas to meet debt service and dividend payments.

Many financial innovations are now being discussed to attract private capital into power projects both in the North and the South, but the driving force behind most of them in the South is the need to isolate financially viable power investments from financially unviable (indebted) economies. Many of the proposed schemes derive from Limited Recourse Financing or Concession Financing schemes where banks, equity investors and contractors "get their hands directly on the cash flow". Such schemes derive from the early 1970's and were developed to reduce the risk of North Sea oil exploration by raising finance on the back of anticipated future revenues rather than on the whole company. In developing country markets such schemes are considered attractive not only because conventional finance is not available, but it coincides with the desire of many developing countries to "obtain longer term commitments from contractors by imposing equity requirements and technical and operating support on potential projects".

Financial institutions in the North are quoted as being forced into such non recourse deals "because of the restraints banks have imposed on adding to their existing sovereign risks... Putting up equity is now regarded by consortia as a cost to the deal".

The most common form of non-recourse finance are BOT schemes (Build Operate and Transfer) where the contractors have the responsibility to build and operate a facility efficiently and in return they get the rights to sell the produce and rights to a proportion of revenues for a fixed period after which the facility reverts to the project sponsor (usually the utility).

While considerable hesitation surrounds the viability of such schemes in the power sector, particularly as a result of the apparent failure of a large BOT scheme in Turkey associated with the sale of Australian coal, successful schemes have been developed in many parts of the world. In the

power sector, Citicorp was able to put a non-recourse package together for the \$200 million gas fired co-generation project in the US at Hopewell Virginia. Morgan Grenfell also constructed a \$1,225 million package for a private lignite fired power plant in Northern Ireland (though this was later cancelled by the government).

But despite apparent successes, the major barrier facing such schemes in most developing countries arises from the fact that power projects are rarely able to generate foreign exchange directly. For the schemes to work, a deal has to be struck not only on the purchase price of fuels and the sale price of power, but also on the amounts and terms under which local currency revenues can be converted to hard currency and repatriated. There are a few exceptional cases such as enclave projects or projects spanning more than one country in which direct foreign exchange earnings are possible. An example of this type is the non-recourse financed Katse dam project in Lesotho which will supply and power for sale in hard currency to South Africa.

But one thing is clear; the backers of low recourse finance will expect high profits at the end of the day. Such schemes will therefore not provide large amounts of cheap power to poor countries and may well lead to funds being attracted to power projects that would have been more usefully spent on more pressing infrastructural investments - whether it is worth it depends on judgements whether the private funds are in fact additional or merely diverted.

Finance will continue to form the main constraint to power sector development in developing countries. The prospects for relaxing this constraint appear slight. Future trends imply the use of funds that are inherently unsuitable for the power sector: terms that involve grace periods that are shorter than the time required to construct projects; pay back conditions that are considerably shorter than the asset's effective life; and rates of interest that heavily discount the future and favour technologies with relatively lower capital costs and higher running costs (principally using higher cost fuels).

Such trends might tip the balance in favour of investing in human capabilities and the efficient operation and maintenance of the existing stock of capital equipment, rather than the purchase of new equipment (i.e. redressing the balance between capital and recurrent costs).

The only counter balance to such trends will be the concern in the north for the environment in general and global warming in particular. Such concerns are likely to militate towards the use of fuel efficient technologies and technologies that are not based on fossil fuels, most notably hydro and geothermal sources. These will tend to have relatively high capital costs, low recurrent costs and may well need to capture the benefits of large scale operation.

2.5 Policies for Power Sector Development Proposed by the World Bank and Other Development Agencies

The World Bank was set up after the Second World War to provide long term finance on soft terms to finance the infrastructure required for the development of poor countries. Its express purpose was to fill a gap that private financial markets would not or could not fill: profitable projects in financially precarious economies which had long pay-back periods. The World Bank and other bilateral sources supplemented scarce domestic savings and in many cases provided much needed technical expertise. Much of their funds and efforts were directed to the power sector.

However, the role of the World Bank was substantially reduced after the oil crisis, as the commercial banks began to finance power sector projects. For instance, the share of the World Bank in the electricity sector investments of developing countries was reduced from 10% to 5% between the 70's and the 80's. Conversely, the role of private banks increased substantially; for instance, in Latin-America the share of private banks in total electricity sector debt was 70.1% in 1987.

With the current reduction in the flows of private finance to the power sector, the World Bank is reviewing its policies.⁷ Even during the period of the 1970's when private finance was plentiful, the Bank tended to set the overall framework in which all finance was structured. But now the World Bank and other donors are again providing a high proportion of project finance, there is a tendency for their scarce financial resources to be concentrated in a few countries that are particularly "responsive" to the Bank's policies. The success of policies in these target countries is thought to offer a model for other countries "unresponsive" to their policies.

This current policy review has some of its roots in the findings of a study of 300 power projects financed by the World Bank between 1965 and 1983. A major conclusion of the study was to question whether the pursuit of expansion of electricity supply is "possible or indeed desirable". This proposition was supported by two main findings of the study.

First, developing countries had been quite successful in extending the access to electricity to a larger share of their population. The average growth rate of connections was 2.5 times the average rate of population growth, thus widening the opportunities for economic development. Furthermore, installed capacity and per capita electricity generation in developing countries had increased, and both were substantially above GDP growth.

Second, the performance of developing countries' utilities deteriorated over time, and this decline in performance "has been paralleled by a shift towards large monolithic public controlled electric utilities". Network losses far exceed those of industrial countries (8%) and reached 21% in Africa; project lengths were 44% above planned construction time; demand forecasts were 20% above actual consumption; under-investment in distribution generated bottlenecks, while over investment in generation produced supply overcapacity; etc. These problems were largely responsible for the rapid deterioration of the financial situation of developing countries' utilities.

The study recommends that greater emphasis should be put on "efficiency and restructuring issues rather than concentrating on expansion". It recognized that such a strategy would lead towards lower electrification both in rural and urban areas, therefore reducing the opportunities for economic and social progress for many people. The report argues, however, that it is not possible to sustain the rhythm of expansion of the electricity system of developing countries if the current poor technological and economic performance of their utilities is not substantially improved.

But it is worth noting that if such a strategy were enforced it would be likely to harm, in particular, the development of those countries that

have not already extended their grid to most of their territory and population; this means that low income countries are likely to suffer most, and this in turn would further increase the gap between the poor developing countries and industrial countries.

The policy guidelines recommended by the World Bank can generally be grouped under three main heads and are summarised below:

a. Institutional Changes - Developing countries should consider institutional arrangements for their electricity sector that will strengthen the role of market forces. It is argued that management of public utilities cannot resist the political interference that is a major source of inefficiency in this sector. Management of utilities should be allowed to run their day-to-day business in a way that is free from political interference, but remain accountable for their decisions. Privatisation is expected to eliminate this interference by government on management. It would also introduce competition and decentralize the decision-making process, thereby creating the necessary environment to improve financial and technological performance of developing countries' utilities.

b. Financial Arrangements - Prices of electricity should be increased substantially and should reflect marginal costs; this would ease the huge financial crisis of developing country utilities and would increase their level of self-financing.

However, it is expected that private funds from both domestic and international sources would have to play a more substantial role in financing developing country ESI's, especially in view of the Bank's conviction (reported earlier in this chapter) that the bulk of developing country power investment needs in foreign currency cannot come from aid agencies.

In order to attract private capital to this sector, the study suggested that a set of incentives must be offered by developing countries in order to reduce risks, particularly to foreign investors: tax breaks, easy access to land, exemption from import duties, security of (profitable) prices, guarantees that profits can be repatriated in hard currencies, etc.

It also suggested that future expansion might be primarily oriented to technologies of low capital-intensity, such as natural gas, to reduce the maturation period of electricity projects.

c. Management Review - Management priorities should be reoriented to reduce losses, and to reduce demand, and there should be a careful assessment of links between the development of ESI and the macro-economic situation of the country. Maintenance and rehabilitation should, therefore, receive much greater attention from management; policies towards electricity conservation and load management should be introduced by utilities; reserve margins and engineering standards should be reviewed to adapt the electricity sector to the social and economic situation of developing countries.

Current thinking such as reflected in the World Bank report, stems not only from examination of past performance, but also from events and ideas circulating in the North. These forces are the subject of the next chapter.

FOOTNOTES

1. A World Bank report suggests that 57% of a sample of 47 power plants supported by the World Bank between 1966-83 have a self financing ratio of 20% or less while 78% have a ratio of 30% or less.
2. It is not clear whether these estimates equate local costs with local content - Korea achieved a genuine local content of 66% in the Geo Jeong Thermal Power plant in 1979.
3. These data are for OECD countries. The total net resource flows from the OECD, eastern European, Arab and other LDC donors in constant 1987 prices were \$169.4 billion in 1987 and \$94.8 billion in 1988. By 1988, the proportion of the total that came from private flows had fallen to 32.4%.
4. Official Development Assistance or oda are official grants and concessional loans to developing countries.
5. These figures are only approximate in that the original source aggregates data for 1987 for some countries with data for 1988 for others.
6. This excludes the huge investments required to use the power.
7. This section is based on documents published by the Industry and Energy Department of the World Bank. While it is argued that these documents do not reflect the views of the Bank but nevertheless the views present in these documents are often used as a guide for policy-making by officials of both the Bank and other lending institutions.

CHAPTER 3 ISSUES IN THE ELECTRICITY SYSTEMS OF INDUSTRIALISED COUNTRIES

3.1 Introduction

In this chapter there is an attempt to delineate the major policy issues and responses that have characterised the electricity systems of the industrialised countries in recent years. In choosing the particular issues on which to focus most attention in so short a space, two criteria have been applied. The first is the kinds of issue which Chapter 2 identifies as the main concerns of the World Bank in its recent policies towards developing countries: the second, which substantially overlaps the first, is the desire independently to review electricity issues in the North which may be of particular interest to the South.

Building on Section 2.1 of Chapter 2, the first main section of this Chapter (3.2) concentrates on the major changes in ownership, structure, organisation and control to which the utility industry has been unprecedentedly subject in the last few years. The second (3.3) concerns the nature of the technological changes, both on the side of electricity supply and electricity use, which are affecting the industry. The third (3.4) covers the major environmental issues which are becoming increasingly influential in determining the direction of a wide range of utility policies. The interactions between structural/control, technological and environmental issues are pervasive, and there are no uniquely prime causes: nevertheless the strong focus on structure and control issues reflects the much increased importance which these have had in recent years in the industrialised countries, and the attention which developing countries are being encouraged to give these questions (see Chapter 2, Section 2.5).

It is also worth noting at the outset that this chapter pays no systematic attention to the industries which supply plant and fuel to the electricity system. This is not because there are no important issues in this area: rather that the utility is the fulcrum around which the electricity system balances, and the procurement issues in the North seem generally less directly relevant to the South.

3.2 Institutional Change: Ownership and Regulation

A consequence of the various pressures enumerated in Chapter 2, Section 2.1 has been a high level of activity in the reform of the institutional structure of utilities in recent years. This process is itself far from complete. Historically, the main changes in utility organisation have been towards greater concentration, as the originally mainly local or rural structures became consolidated as technology scale increased, and towards increasing public ownership as private companies became absorbed by local and central government. As late as the 1960s, these processes were still quite powerful (e.g. the consolidation and taking into public ownership of the Italian system in the 1960s). Nevertheless at the start of the 1980s the institutional structure of utilities was highly variable across the industrialised countries. At one pole there were the centralised, vertically integrated, publicly owned utilities that have characterised some European countries e.g. France, Italy, and until recently (in practice) the UK. Then there is a wide range of countries with mixed ownership structures (the public part often being municipal rather than national para-statal), usually with integrated utilities having regional rather than national monopolies (e.g. Germany, Sweden, Netherlands). Close to, though not quite at the other pole are systems which are almost entirely privately owned (e.g. US, Japan) but also having regional monopolies and variable degrees of integration. Available evidence is that there is no systematic variation in economic or technological performance according to ownership or structure.

In the discussion of why existing utility structures had become inappropriate, there often tends to be an elision between three separable types of problem that may afflict utilities. These three problems are:

1. Centralisation and excessive size (including, often, a high degree of vertical integration) leading to problems of inflexibility and unresponsiveness.
2. Public ownership, which can lead to excessive political interference and various forms of inefficiency.

3. Monopoly which, in classic economic reasoning, may lead to forms of inefficiency and exploitation.

The one element that was more or less universal in industrialised country supply systems until the early 1980s was a very high degree of monopoly. This monopoly extended beyond the 'natural' areas of bulk transmission (the grid) and retail supply of small, mostly household, consumers: it included retail supply to large customers and electricity generation, neither of which exhibit classic natural monopoly tendencies. This in turn has meant that the more or less common element in efforts at reform and re-structuring are (and are often centred on) attacks on aspects of the monopolies embedded in most systems. In particular there has often been an attempt, especially in Europe, to break up the vertically integrated structure of many utilities: an integration that has tended, whatever the legal forms, to provide overwhelming obstacles to non-utility participation in the public supply of electricity.

However beyond the reduction-of-monopoly theme, there have been significant differences in the practice of reform. Broadly, two major approaches can be identified: those that concentrate on questions of changes from public towards private ownership (usually in concert with some changes in organisation), and those that (irrespective of ownership) have been mainly about changes in regulation.

A. Ownership and Organisation

Clearly the most radical model here is that of Britain, which is (uniquely) simultaneously tackling ownership, monopoly and centralisation/size issues all at once. The changes taking place are part of a longer term strategy to transfer into private ownership very large parts of the economy that until 1979 were publicly owned. The early focus, as in the cases of telecommunications and gas, was on the transfer of ownership, with no serious structural change. Thus monopolies were left largely intact, and a new system of more or less transparent regulation was relied on to keep monopoly abuses in check. Some disquiet with these earlier efforts led the Government, in its proposals to privatise electricity, to insist that competition would be a cornerstone of this particular privatisation. This is also unique to Britain: no other reform proposals have elevated competition to the role of central organising principle for the industry.

A measure of the weakness of some utilities in resisting pressures for change in the British process is that the Government was able completely to set aside the lobbying effort of the incumbent utility (the CEGB) to be privatised in its existing form. Instead, the CEGB - previously responsible for generation and bulk transmission in England and Wales - is to be split into two generating companies, plus a transmission company. This transmission company will be owned by the 12 regional distribution companies, which will be private versions of the existing 12 state distributors. (Scotland, which contained two linked and vertically integrated companies, is to be treated separately, and little structural change is envisaged there.) A powerful regulator would be responsible for economic policing and setting the rules of the new game.

The proposals have encountered many difficulties, mainly because, in a very short time, the Government has attempted to introduce fundamental competition into the new structure. The two large generators are expected to compete with each other and against new entrants to generation; generators and distributors are to compete directly for large industrial customers; and distributors are to compete with each other both directly (for industrial consumers) and indirectly via yardstick measures. Such a radical set of proposals is unprecedented. While other reforms have aimed to introduce competition in limited market segments and in circumscribed ways, all other electricity systems have been characterised fundamentally by cooperative structures, within which some marginal competition may take place.

In practice, it has proved problematic to achieve these ambitious Government objectives. First, it has proved impossible to sell nuclear plant to the private sector, and the nuclear construction programme has been cancelled in the financial confusion surrounding the attempt to sell existing nuclear assets. Second, and in some ways more important, the Government has been forced severely to limit the scope for competition in the early years of private ownership, as the various parties to the new competitive arrangements could not voluntarily agree workable new structures. The difficulties concerned both the technical problems of operating the system and planning new capacity in a way that would not be disruptive to supply and which would achieve cost minimisation, and the

allocation of commercial risks between the parties. In the end, the system looks likely to dispatch power on a similar basis to that now operating (the 'merit order'), and limits have been proposed over the first eight years to the proportion of any distributor's load which can be competed away by generators. Thus most customers are supposed to remain captive to their local distribution company for some years, and the scope of inter-distributor competition now looks likely to be seriously circumscribed.

Certain problems remain to be resolved, particularly the legality of allowing some consumers to sign cheaper direct contracts with generators while others are disallowed from so doing, and whether or not in the industrial and even the domestic market the traditional utility obligation to supply will be abandoned completely in favour of entirely competitive principles. It is clear from the British experience that competition, if it is to emerge, has to be managed very carefully, and that whether or not competition becomes an important feature of the system, there is a need for new and demanding forms of regulatory activity if a private industry is to operate in a politically acceptable way.

No other industrialised country has attempted major changes in ownership of utilities. The Netherlands has undertaken a transfer of assets between existing companies to secure a greater concentration in the overall structure, but without any significant ownership changes. The attempt has been to reduce the number of generating companies from 15 to 5, to reduce the number of distributors, and to separate the distributors (in legal and accounting terms) from the generators. This attempt at vertical disintegration has taken place in a system in which the distributors still indirectly own the generators: it depends on SEP, the transmission company, being made more autonomous. This, it is hoped, will allow for some competition among generators in selling power to the grid.

Among other countries, Portugal also plans to undertake vertical disintegration of its state monopoly EdP, into three companies responsible for generation, transmission and distribution. These will continue in state ownership, though there are plans to allow competition in the tender for the next power plant to be built, mainly to reduce utility/Government financing burdens.

In Germany there has been a degree of privatisation, via the sale of the state holding company VEBA and of parts of some locally owned utilities. Further changes in 1994 will involve the renegotiation of franchise arrangements between distribution and generation companies, where there is likely to be some competition to supply the distributors.

In Austria there has also been a partial privatisation, both of 49% of the state production and transmission company, and of a minority of shares in some provincial utilities. In Spain, a major re-structuring in the early 1980s was mainly designed to cope with the aftermath of a financially disastrous nuclear investment programme. Some private utilities had to be rescued from bankruptcy by the state, and in the process the state-owned transmission/co-ordination company ENDESA was strengthened. It has subsequently been partially privatised, and further private utility mergers have taken place.

B. Reforming Regulation and Competition

In general, regulatory reforms - measures which change the conditions of access to the supply system, or mechanisms of scrutiny, but without formal structural change - have been rather more widespread than major re-organisations. The effects of such changes can be potentially at least as radical as those which involve structural change. The most important of the regulatory changes have concerned the issue of common carriage, where consumers and other non-utility users can use a network directly, paying a transmission fee, rather than purchasing power from the utility.

The country which has seen the most significant changes is the USA. Because of the variety of state and federal forms of regulation the results have not been even. In the states, there has been, as a result of a critique of the adequacy of rate of return regulation, some attempts to improve the signals given to utilities. Thus in much of the reform the idea of incentive regulation has been introduced. This gives utilities a number of targets covering different aspects of its operation, rather than a single investment rate. If the utility succeeds in achieving its targets, it may be allowed to share some of the benefits by earning a higher rate of return. Public Utility Commissions may also be able to devise yardsticks by drawing on the experience of other Commissions.

Federally, the focus has been on mechanisms to establish more market instruments into the industry. PURPA, from 1978, was originally intended to encourage greater energy efficiency and diversity by requiring utilities to buy power on favourable terms from industrial cogeneration or renewable sources. It has encouraged the development of a major new programme of cogeneration at a time when utilities were unwilling to invest in new power plant. The next stage in PURPA involves a system of competitive bidding for new power plant. But while PURPA tackled the issue of allowing independent generators access to markets, it did not tackle issues of more general access to the grid, which would include the possibility of direct generator/consumer sales and a choice of utility on the part of industrial consumers. The 'wheeling' question is still under review in the USA.

It is worth noting that in the USA there has been little attempt to undertake any disintegration from the highly vertically integrated character of utilities, and indeed some pressure from the deregulation lobby is towards allowing further horizontal concentration: that is, allowing mergers and takeovers between the (currently very large number of) local integrated utilities.

The access question is the principal regulatory issue in Europe, and attempts to improve access have been made beyond the UK and the Netherlands. The motivation has varied: in some cases it is pro-competition while in others it has been for better exploitation of resources and energy efficiency (sometimes with an environmental reason). Generally the procedure is to offer improved terms of purchase from independent producers, often with particular encouragement to small scale sources. However little progress has been made in the area of access for large industrial consumers.

C. International Issues

Utilities in industrialised countries have been always organised overwhelmingly on a national rather than an international basis and although this remains true, in recent years there have been some moves toward a greater international integration of systems. The background has been, as in national systems, a set of relationships between utilities that are predominantly of a cooperative rather than competitive nature.

The most important trend in recent years has been towards an expansion in international electricity trade. In Europe national systems have become increasingly strongly interconnected, and trade has risen from 1% of total sales in 1950 to 5% in the 1980s, with some specific trades much larger than this figure implies. In the 1980s the principal stimulus to enhanced trade has been the large surplus of French nuclear power, and low cost sales to neighbouring countries has been unproblematic. Difficulties have arisen in two specific areas. The first is the attempt, especially in relation to Portugal and France, to buy power via an intermediate country (Spain). This led to a dispute over the price to be paid to Spain, and under European Commission auspices a solution has been found to this specific issue. The second is the possibility that industrial consumers in one country might buy directly from a utility in another country. This emerged in the context of German firms wanting to buy (cheaper) French electricity directly, and the resistance which this provoked in German utilities. The German/French dispute was settled with an expansion of direct utility to utility sales across the border, but it raises the very important issue of access and common carriage across national borders.

The disputes mentioned above were solved partly through the influence of the European Commission, which has also become much more active in proposing expanded trade in electricity. This has been mainly in the more general context of the proposals for a Single European Market. Electricity receives special attention in the Commission's proposals for a Single Energy Market. Besides encouraging new procurement practices which avoid national preference and draft proposals on greater price transparency for industrial electricity sales, the Commission has been making initially radical proposals to open up a single electricity market. The idea here is to induce both operational and investment planning changes throughout Europe (though not ownership changes). The potential savings have been estimated at up to 3 billion ecus, although the practical proposals are necessarily much more limited at this early stage. Early moves include establishing the right to trade between any utilities in the EC area and encouragement to investment co-ordination. Eventually there will be an attempt to raise the open access issue across borders but consideration of this has been postponed until 1992.

In North America there has been less in the way of formal changes to structures though the 1988 US Canada Free Trade Act has been of some use. The level of trade in North America is only 2% of sales, but for New

England it is as high as 10%. The trade is virtually all from Canada to the US and negotiated by the states and provincial utilities involved. There are some misgivings on the part of some US raw material suppliers and some Canadian environmentalists, but it seems likely that the level of trade will continue to grow.

3.3 Technology

The first point is the low overall level of investment in new supply side facilities in the 1980s. This is for a variety of reasons: the existence of plant surpluses as a consequence of over-high demand forecasts in the 1970s, combined with lower experienced and expected rates of growth of electricity demand; the higher rates of interest faced by utilities, often reinforced by a more 'private sector' approach to investment decisions (ie the use of shorter time horizons) even where there has been no privatisation as such; and the higher real resource costs (net of the cost of money) of some traditionally favoured options, especially nuclear power. It is arguable that increasing public opposition to large new power construction - especially on greenfield sites - may also have led to a slowdown in investment in some countries. To the extent that high rates of interest and more market-oriented investment criteria have been important, there has also been the start of a re-distribution of investment towards lower capital cost, higher fuel cost technologies which tend to offer quicker paybacks than traditional larger scale options.

There are a number of general issues that cut across the details of specific technology and investment choices. These are questions of scale, of new actors in the investment process and of efficiency (the latter related to, but not identical with, energy conservation and the demand side of electricity systems).

A. Scale

The traditional assumption has always been that economies of scale are available from increasing the size of individual generating units and of systems as a whole. These views have increasingly come into question in recent years, especially in relation to individual plant size. There is,

first, general agreement that there are no significant economies to be gained from larger unit sizes than the largest that were developed in the 1970s ie around 1300 MW for nuclear power, and somewhat less for fossil fuelled units. More controversial is the idea that diseconomies set in at unit sizes lower than these maxima, and therefore that lowest costs attach to medium-sized units rather than the largest. For nuclear power there is some evidence from France and Canada (in construction cost terms) and from the USA (in operating performance terms) that units of less than 1000 MW are cheaper - in total generating cost - than larger units. For fossil fuel units of conventional design, the evidence is less clear: but it does seem likely that in the range 300 MW to 1000 MW the differences in unit costs are no longer very large, though there may be still be some advantage to larger size.

More interesting perhaps is the idea that the newer technologies - particularly combined cycle gas, and fluidised beds - are just as economic at small size as at large sizes. This is an area where definitive results are not available yet. What is clear is that the economics of small (100 MW to 300 MW) combined cycle and fluidised bed plants compare favourably with the economics of traditional generation at larger sizes. This does not in itself however prove that there are no economies of scale: only that newer technologies may be more economic than older ones. The fact that the size of units available in these technologies is currently small does not necessarily reflect the superior economics of small sizes in those technologies. It rather reflects the fact that new technologies always start out small. The real test is whether or not there are reductions in unit generating costs as fluidised beds and combined cycles are themselves scaled up. This scaling up process is already beginning to happen with gas turbine technology. Of course it is possible that these technologies will not scale up cheaply: equally possibly, they might do so, in which case the idea that developing countries will not be at a disadvantage if they need to buy small plants may be a temporary phenomenon.

The advantages of scale in relation to system size are still widely regarded as important, but there is no evidence that systems become indefinitely cheaper as they get larger. Thus while, in order to accomodate plant sizes of 1000 MW it will usually be necessary to operate systems of 10 GW or larger, it is not clear that further advantages accrue

to yet larger system sizes. Indeed insofar as larger systems may run into centralisation/inflexibility problems, there may be diseconomies in very large system sizes.

B. New Actors and Efficiency: Supply Side and Demand Side

The ideas of new actors and efficiency are related to these scale points. Traditionally it was always supposed that economies of scale in individual plants, and system economies from grid integration, were the virtually sole motors of economic/technological progress in electricity supply. However the increasing ambiguity of scale effects and the completion of most grids, combined with new technological developments in both supply and demand sides of the equation, mean that efficiency is no longer necessarily best pursued by further expansions in large-scale units in centralised utility systems. Centralised utility companies, with responsibility for large-scale public power supply, have not generally had the flexibility to respond to these opportunities very effectively, with the result that many new investments in power supply have been taking place outside the utility sector completely. The USA is the best example of this, though here the economic incentives have been strongly affected by PURPA, which compels utilities to buy unlimited quantities of power at fair prices from any 'qualifying facility'. Be that as it may, hardly any power investment in the 1980s in the USA has been by utilities, but a great deal has come from industrial electricity users and other companies. This has been accompanied by a great surge in co-generation.

These are in addition new, very small units which also introduce new actors. These are at the 1 MW level in small (building-based) CHP which may, provided heat loads are effectively utilised, compete very effectively against grid-based power. The introduction of such technology, already apparent in countries such as Japan, requires either a high level of dispersed technological capability, or the existence of a sophisticated market in energy management, where specialised companies market energy savings to small economic units (factories, hotels, swimming pools etc). But there are signs that this kind of dispersed power system could become much more widespread in the 1990s.

Efficiency can also be increasingly pursued by means of stress on the demand side of the electricity system. Certainly the movement away from utilities as the sole focus of supply side investment activity has also

been paralleled by a movement away from the supply side as the sole focus of electricity system investment. This emergence of strong opportunities to invest in electricity saving has also helped move the centre of gravity of electricity supply systems away from utilities and towards their customers.

Again the US has been prominent, partly stimulated by a particular regulatory climate in which supply side investment has been systematically discouraged. Utilities have developed innovative techniques of least-cost planning, which integrate supply and demand considerations, and have the effect of giving much more prominence than previously to demand-reducing investment. But there is much more to the story than simply discouragement to the supply side. A range of new technological developments has made electricity saving more cost effective, in many situations, than new electricity supply. It is true that energy saving in general has been more associated with non-electric carriers than with electricity. The growth rate of electricity use has tended to be substantially higher than of the fossil fuels, and there has been a common (and not always inaccurate) assumption that electricity will tend to substitute for other forms of fossil fuel use. However the forces leading to reductions in energy use per unit of output in fossil fuels have also operated in the electricity case: the main difference being that as new uses are found for electricity as a result of both fuel substitution and new technologies, the statistically observed savings in electricity use per unit of output tend to be lower. It is also true that policy towards energy conservation has tended to concentrate on direct use of fossil fuels (indeed there was a powerful vision in most industrialised countries, now quite redundant, that cheap nuclear electricity would gradually mop up virtually all non-electric demand for energy). However there has been a change, notably in the USA, but more recently in Germany and the European Community, towards targetting conservation policies particularly on electricity.

In the US case, demand side investment - often made or at least paid for by utilities - has often been a matter of buying out demand because of the virtual impossibility of expanding supply. But there are also many technological developments which encourage electricity saving: these include new metering technologies which make possible a much more interactive relationship between utility and customer, reinforced by more

sophisticated pricing systems, and a substantial improvement in system load factors (thus reducing new investment needs). There are also substantial changes in the energy efficiency of many electric appliances, especially in the dominant cases of motors and lighting, which in some cases like motors, involve substantial retrofitting possibilities. It is widely observed that market imperfections prevent many cost-effective conservation investments from being undertaken, and that (outside the US) many lower-return supply side projects are undertaken in preference. It would be unrealistic to suppose that all these market imperfections will be overcome, but emission control considerations are likely to give a substantial further boost to electricity conservation.

It is also important from the viewpoint of relevance to the South to recognise that improvements in electricity efficiency in the North have by no means derived entirely from responses to relative energy price changes or purposive but narrowly focussed energy conservation policies. In the periods before 1973, energy efficiency in industrialised country industry improved over a very long period, despite falling real energy prices and the absence of purposive efficiency policies. This was no doubt due in part to the fact that successive vintages of industrial technology embodied lower levels of energy intensity. However there is also a growing body of evidence that much of the improvement in electricity and energy efficiency in industrialised country industry stems from wider technological capacities in industrial firms. Thus the energy efficiency of industrial processes is sometimes observed to improve sharply after installation, and sometimes to levels beyond design intentions, but without significant new investment expenditure (and none on 'energy efficiency').

Such large improvements in the electricity/output ratio seem to have been achieved by a process of continuous and incremental innovation, not all or even most of it specifically directed to energy saving ends. Capacity to improve the post-investment performance of electricity-using technology seems likely to have been a major factor in restraining the growth of electricity use in industrialised countries. This is an important issue often not recognised: that the energy (and for that matter economic) efficiency of industrial investment is not set in 'clay' at the moment of the installation of new equipment. Efficiency can either greatly improve, and equally well, greatly decline, depending on the technological

and managerial resources available to operate and improve upon initial performance. However, the policies and approaches required to achieve efficiency improvements often seem to lie outside the realm of energy efficiency policy, and to be instead in the domain of the accumulation of general technical capacities within firms. The more limited presence in many developing countries of such resources may inhibit the rapid achievement of electricity conservation, irrespective of the level of overt energy efficiency policies.

C. Supply Side Technologies and Fuels

There has been a major shift in the distribution of investment among the various supply side technologies and fuels available.

Nuclear Power - It was widely expected in the early 1980s that nuclear power would constitute a large share of incremental capacity. By contrast, nuclear power has become a less and less attractive option. The prospects for any substantial nuclear ordering in the next few years are confined to Japan and one or two other NICs, especially Korea. In Europe and North America, nuclear is certainly dormant and prospects for revival may now depend on radically new technology.

The reasons for the fall from grace of nuclear power are complex, and by no means uniform from one country to another. In the USA, one explanation is that real nuclear costs have risen very rapidly. In a private sector investment climate, the financial risks of nuclear are also very high; finally, there has hardly been any investment in large, base-load plant for around a decade. Even if large scale plant is ordered in the near future, the risk/cost problem for the private sector will prove too large an obstacle for some time to come.

More generally, nuclear has suffered from the strong downward movement in real fossil fuel prices ever since 1981, with the period since 1986 a particularly difficult one. At the same time, the real costs of nuclear power have steadily risen. At the front end, the real cost per kW of nuclear construction has increased, mainly because of the powerful impact of new environmental/safety regulations on design. Combined with much higher real interest rates, the cost of financing nuclear plant is now very

much higher than it was a decade ago. While uranium costs have fallen, they have been a very small constituent of total costs, and in the meantime other operating costs (maintenance, repair and post operational capital expenditures) have generally risen steeply. Finally, the costs of the balance of plant have also - so far as they can be defined clearly - also gone up sharply. Thus much more rigorous environmental standards of waste disposal, plus the discovery that decommissioning is liable to be much more expensive than had been earlier anticipated, have led to much higher current provisions for future nuclear liabilities.

There remain a few countries, with relatively low nuclear costs (eg France and Belgium) and a continuing political commitment to nuclear power. They are most unlikely to form a significant source of new demand for nuclear plant because their systems are already full, or especially for France, over-full, of nuclear capacity. The counteracting of global warming is now almost the only possible way back for nuclear.

Renewables - This can be divided into hydro and the newer renewables like wind and solar. In the hydro area, there has been little new activity, and this is likely to continue. Most large sites in industrialised countries are already used, or, as in Scandinavia and central Europe, raise intractable environmental problems. There has recently been some activity in micro-hydro in such countries as Holland and Portugal, but the overall contribution is small.

Investment in the newer renewables has not been extensive, but in the USA and some European countries like Denmark, there has been some activity, particularly in wind turbines. Much of this activity has resulted from particularly favourable tax and subsidy regimes (especially in the US) which are now largely coming to an end. While wind power will probably continue to make some advances, renewables, as almost entirely front-end loaded investments, suffer even more than nuclear from the high cost of capital. Technical advance in renewable technology, while real, has not been sufficient to overcome this problem. Photovoltaics have not yet reached economic viability except in very specialised uses, and wave and tidal schemes are limited geographically, tend to have high capital costs/kW, and raise a range of environmental difficulties. It is difficult to see renewables making a very much larger impact in the 1990s except

where special protection is given (as in the reservation of a tranche of 600 MW for renewables in the British electricity privatisation).

Although not renewable in the same sense, refuse has become a focus for some new power sector investment. This can be either agricultural waste, as in Denmark, or urban/municipal, as in Scandinavia and the USA. While the total contribution is by definition limited, there is likely to be more activity in this area, partly motivated by environmental considerations, particularly the combustion of land-fill methane as one contribution to counter global warming.

Coal-fired generation - There has been limited new activity in coal-fired construction in recent years (most new construction has been in the NICs). This partly reflects limited total demand for plant and high costs of capital, but it is also increasingly to do with a range of environmental difficulties associated with coal burning, following the relative failure of super-critical units in earlier years. There has been significant retrofit activity in flue gas desulphurisation technology (eg in Germany) and this is likely to continue. There has been a significant search for cleaner (in SO_x and NO_x terms) ways to burn coal: this has resulted in the commercial development of fluidised beds, which are just beginning to sell, in relatively small sizes, to power markets (utility and non-utility).

Hydrocarbon generation - There has been virtually no activity in oil-only plant, but a recent and rapidly growing interest in gas turbine technology, both in closed cycle, but particularly in combined cycle (with a steam turbine). There are now a very large number of gas-turbine-based schemes going ahead in industrialised countries. There are a number of reasons for this. First, natural gas has become more plentiful and cheap in the short term. More important, this has led to expectations that gas will remain plentiful and cheap, and there has been a definite shift in the perceptions about gas: away from the idea that it is a premium fuel too precious to burn in power stations, towards a view that it is a commodity like any other. Second, there have been significant advances in gas turbine technology. This has meant that gas turbines are, in particular, now much more reliable in continuous operation than a few years ago; and they are likely to be increasingly available in larger sizes than the 50 -

150 MW units that have been most common so far. Thirdly, gas turbine technology offers the lowest capital cost/kW of any commercially available form of generation, and it can begin to provide power within two years of the commitment of funds. This makes it enormously attractive in a high interest rate environment. It will, however, correspondingly put industrialised country electricity systems on to a significantly higher price trajectory to the extent that current plans for gas turbine expansion are fulfilled.

A substantial amount of new gas-fired generation has also been undertaken in co-generation schemes. These have predominantly been small-scale industrial schemes, and have generally taken place outside the utility sector (especially in the US), though they have often sold significant segments of output into public supply. The emergence of gas as a major power station fuel is one of the most significant new developments in industrialised country ESIs. Originally motivated by purely technological and economic motives, the use of gas will undoubtedly be much enhanced by new environmental needs in the power sector.

3.4 Environment

A. Issues Covered and National Differences

The idea of environmental harm is, in English usage, exceptionally broad and can cover issues as diverse as visual impact, congestion, noise, air pollution, acid deposition, solid wastes, radioactive contamination and global warming. It is important to distinguish initially the three main categories, spatially, of environmental harm that have had importance in industrialised country electricity systems.

The first and longest established set of issues are those which are essentially local and site-related. Issues have concerned, for example, the visual and amenity impact of large new power sites; the local pollution impact of waste sites or mining operations; and the ecological and human impacts of hydro developments. Concern about such questions has a long history in industrialised countries and has been important at a policy level for the last two decades in many of them.

The second set of issues concerns what we can call 'regional' issues. The impacts here may extend for tens or hundreds of miles beyond individual sites, and so in some areas (e.g. W. Europe) there may be an important transfrontier dimension to the resolution of problems. Examples are radioactive wastes (airborne or seaborne) and - a subject of intense political attention in the 1980's - acid deposition. These regional issues are given particular attention here.

The third set of issues, or rather single but potentially catastrophic question, concerns global warming, in which the power sector plays a significant role. While the subject of much recent debate, global warming has not yet had serious impacts on industrialised country policies.

It is equally difficult to make general statements about the perceptions and policy responses of the industrialised countries to this range of questions. Even where a conscious attempt is being made to develop common environmental approaches, as in the European Community, these remain major differences and conflicts between national approaches. Thus, Germany and Britain stand at the ends of a spectrum within Europe; at present Britain has yet to complete a single flue-gas desulphurisation retrofit to a power station: in Germany all public supply power plants are so equipped. Even after the completion, thirteen years hence, of a European regulation such as the Large Combustion Plant (LCP) directive, environmental standards will not necessarily be harmonised. The LCP is a minimal approach: individual countries may choose to apply more stringent standards.

It is possible to generalise to the extent that the environmental impacts of the electricity system are now widely perceived to be pervasive in the industrialised countries. In some areas, environmental problems have begun to affect electricity systems in defiance of declared policies: thus local resistance to the siting of large electric power facilities has created obstacles to official plans in a number of countries; while the increasingly stringent levels of regulation in nuclear power have owed much to public disquiet and pressure for tighter standards. Nevertheless industry and Governments have sometimes exaggerated the extent of the practical effect that such public resistance has had on existing policies and plans: in the most obvious case of nuclear power, the effects have

mostly been a reinforcement of other trends that were already moving in the same direction. It is important to remember that when official plans are not fulfilled, both industry (seeking external forces to blame) and environmentalists (keen to claim success for their campaigns) may share an interest in exaggerating the impact of such opposition.

However, recent years have also seen a widespread movement in the direction of environmental policies intended to have an impact on the electricity system. It is clearly the case that environmental consciousness/pressure has played a role in the development of these policies, though other interests have been involved. (It is beyond the scope of this project to analyse the political roots of environmentalism.) There has been some attempt, particularly in the OECD, to argue that environmental protection makes a positive contribution to economic growth in the short term, and that 'technology forcing' regulation itself provides a foundation for future economic growth. In the short-term it seems clear, by contrast, that environmental protection involves significant increases in cost compared to the previous situation. In the longer term, economy-wide costs may be minimized by environmental protection (at least if costs are measured widely enough), but for the electricity system, even in the long term, attention to the environment will mean higher prices, to some degree or other. It is of course true that effective regulation can in principle promote a more efficient or less costly route to a given level of environmental protection than less well-directed regulation: but this is a least-cost argument, not a net economic benefit argument.

While current political attention surrounds the implications of global warming, it is important to notice that environmental regulation in other areas affecting electricity will have further impacts on the electricity system for many years into the future. Thus in Europe regulations on large combustion plant emissions will progressively 'bite' in the 1990s; while in the US under the Bush administration, serious new efforts are being made to introduce legislation which will have far-reaching effects on coal use in power production. It is also highly probable that regulation governing all major aspects of nuclear power will continue to evolve in the direction of greater stringency. In many ways the process of environmentally regulating the electricity industry is only just getting into its stride in the industrialised countries.

Given the very different environmental problems between different industrialised countries, the varying evaluations of the same problems, and the different political/legal traditions of dealing with such problems, an important question is the extent to which environmental control policies and strategies are likely to converge in future years. Clearly in some regions, especially the European Community there is an explicit attempt at achieving such convergence, at least for minimum standards. Interestingly some of the political arguments being used in favour of such harmonisation are to do with establishing a 'level playing field' in the establishment of a unified market. Thus German utilities resisted the import of French nuclear electricity on the grounds, among others, that the French have less rigorous regulation of nuclear power, giving French nuclear power an unfair advantage over German. To the extent that the European Community moves to a situation of reduced trade barriers, it is likely that the harmonisation of environmental standards will become an important bargaining issue in the process.

B. Environmental Regulation

It is clear that effective enforcement of environmental policy requires a well-developed system of regulation, and regulatory problems are significant in the industrialised countries. A serious basic issue concerns the level and accuracy of knowledge about the physical extent of environmental damage and the physical effectiveness of abatement technology or strategies. To the extent that regulation in the electricity system concerns relatively large plant and a limited number of utilities, this problem may be less acute than in other areas of environmental policy, but as the electricity sector starts to become decentralised it may become a more important issue.

Connected to the knowledge issue is the question of enforcement. Different countries have different approaches to enforcement: some are more inclined to direct political pressure, others to emphasise the establishment of physical standards in law. The extent of enforcement is also variable, and while much recent debate has concerned the relative merits of direct physical standards (e.g. plant-level emission limits) and market-based instruments (e.g. tradeable permits), enforcement is important in any system. In practice, market instruments have been little used so far, whatever their apparent attraction on grounds of ~~economic theory~~.
POLICY RESEARCH

The evidence seems to be that external, manifest forms of regulation are more effective than internal regulation within the public sector. Practical enforcement is not always easily achieved: regulatory agencies require a high level of trained competence, with an ability either to undertake or effectively commission research. They also need public awareness and support. When regulatory agencies exist within established bureaucratic structures it has often been difficult to attract and retain well-qualified candidates (as in the UK). And when regulatory agencies are well structured and effective, they can represent significant costs in themselves. Finally, it is important to notice that in a decade when many states have tried to stage a conscious withdrawal (in line with neo-liberalism) from traditional forms of economic and industrial intervention, environmental regulation has in some instances provided a vehicle for new, not always explicit forms of state influence over industrial investment patterns. There is some evidence of this in Germany.

So far regulatory issues have been treated as purely national phenomena. There are of course important transfrontier pollution issues requiring regulation, particularly in Europe, and between the US and Canada. Resolution of transfrontier issues can be even more complex than national ones, especially where there are large differences in style and approach. To give one example: if one country regulates via air quality standards and another by emission levels at chimneys, finding agreement on even what to measure can be a major problem. International enforcement, raising issues of sovereignty, can also be difficult, though the long experience of the IAEA in the nuclear field shows that this problem is not necessarily insuperable. These issues, while important, pale almost into insignificance in comparison with the enormous international institutional problems raised by any serious attempt at dealing with global warming. At all levels - scientific, economic and political/institutional - global warming raises issues that are qualitatively different from (and more difficult than) all the other environmental issues.

Even where specific environmental regulation does not apply to some aspect of the electricity system, there is a strong move (e.g. in the USA and the EC) to subject all new proposals to comprehensive environmental impact assessment.

C. The Impacts of Regulation

One important question about the effects of environmental regulation in electricity is the extent to which the responses involve mainly 'technical fixes' and the degree to which behavioural change is induced. While global warming may well be a case in which behavioural change will play a large role, in the responses to 'regional' issues, technical fixes have been prominent.

To the extent that technical fixes are important, a related question of some importance is the extent to which responses are mainly a matter of 'bolt-on' abatement technology (eg flue-gas desulphurisation). In such cases developing countries may have choices about whether or not to adopt the abatement technology. More likely, however, is that in the longer term, abatement will be designed into the fabric of the basic technology, in which case there will be no such choice. While 'inherency' may well work out more cheaply than 'bolt-on', it is still - if the initial argument about the existence of real opportunity costs in environmental protection holds - likely to lead to more expensive electricity production than if no abatement were undertaken.

Equally interesting is the question of whether higher levels of environmental regulation in electricity will tend to change the terms of fuel competition and to favour some supply sources over others. If there is serious action to try to restrict global warming, there will tend to be an obvious discouragement to the fossil-based technologies, especially those using coal, but significantly oil, and to a lesser extent gas. The nuclear industry is already constructing a scenario in which there will be a kind of bifurcation in environmental consciousness, with increasing opposition to fossil fuels accompanied by increasing enthusiasm for nuclear power because of its favourable global warming consequences. This may be self-deluding scenario: environmental consciousness may turn out to be indivisible, and growing awareness of the hazards of fossil fuels is more likely to be accompanied by further concerns about the disposal of radioactive waste. Given that existing concerns about radioactivity have already led to a long process of stiffer nuclear regulation, it is therefore unlikely that this process will be easily reversed. On the other hand, countries like Sweden may well decide not to phase out nuclear power as quickly as once expected: this, however, may be easier than deciding to build new capacity.

Nor is it clear that renewables will come out of the new environmental consciousness much better: some environmentalists already oppose tidal schemes in the UK, and would be likely to oppose wave power if proposed on large scales. Hydro schemes are already vigorously resisted in the Scandinavian countries. Renewables tend to be physically large projects, and as in wind, hungry for land which may often be perceived as having aesthetic or recreational value.

In practice then the differential impacts of environmentalism on different technologies and fuels may be fairly subtle. There can be no sudden abandonment of incremental use of fossil technologies even on the worst global warming prognosis, and there will therefore be attempts to use fossil fuels in more CO₂-efficient ways. This will obviously favour gas uses (given negligible sulphur content and relatively favourable CO₂ impacts) especially in uses in which thermodynamic conversion is improved. Thus the combined cycle (efficiency up from 37% to 45-50%) will obviously be favoured, as will combined heat and power (together with the combined cycle: total efficiency up to 80%). A combined cycle-combined heat and power plant can approach a production rate of CO₂ approaching three times less than a once through coal-fired unit for a given quantity of energy production. Given the currently low cost of gas and its relative plentifulness coal technologies will face serious problems in a world where carbon and sulphur are both seen as real issues. There is likely to be a powerful incentive towards combined heat and power in coal uses, and towards further developments of fluidised beds, which offer the (inherent) possibility of reducing sulphur and NO_x emissions to very low levels. As well as leading to some new bases for preferences among fuels and technologies, it is clear from this discussion that growing environmental concern will inevitably make conservation a relatively much more attractive option, given the environmental problems attending all supply options, including renewables. This expectation itself depends on conservation requiring investment or action which itself has very limited environmental impact; and in most practical situations this will generally be true.

Finally, under the environmental heading, there is the question of the way in which the technological choices that result from environmental policies will influence the wider pattern of fuel choice in industrialised

countries. Put crudely, will the dirtier fuels be largely rejected by the industrialised countries, and thus be used (because cheaper) by developing countries: or will pollution control technology encourage the use of cheaper and dirtier fuels in industrialised countries, thus allowing developing countries access to relatively cleaner fuels at lower cost? In practice, the choices may be less polarised: indeed one of the ways in which the differences between industrialised country approaches may be manifested is that in some (e.g. Germany) pollution control technology may allow low quality fuels to be used, while in others (e.g. Britain) there will be a demand, say, for low sulphur fuel. In the longer term, the pressure to adopt control technologies may reduce industrialised country demand for 'cleaner' fuels.

3.5 Conclusions

No attempt is made here to summarise the whole range of issues covered in this chapter. Instead a few of the main issues which seem likely to have implications for developing countries are briefly collected together.

In the area of ownership, structure and regulation, the issue of privatisation has been of major importance for Britain, and of relatively limited significance for a small number of other countries, including Austria, Germany and Spain. Re-structuring has been of somewhat greater significance, and serious efforts at change have been taking place in Britain, Portugal, the Netherlands and to some degree in a variety of other countries. Above all, perhaps, the key issue has been new forms of more explicit economic regulation, whether or not accompanied by changes in ownership or structure. Many countries, including the US, Britain, and the Netherlands as well as the European Community as a whole, are seeking new ways in which to regulate the utility industries. This regulatory process is demanding of often new kinds of skill and organisation, and requires political structures which allow arms' length relationship between regulators and Governments of the day.

In these processes, it is becoming clear that while the national state preserves a major strategic role in the ESI, the appropriate unit for much decision-making no longer corresponds to national boundaries. Efforts are

being made on the one hand to institute cross-national trading and planning, while on the other, small-scale technology makes possible more small-scale system operation. There is some divergence in the trends around system scale. Smaller countries continue to concentrate their industries horizontally (Netherlands, Belgium) while large ones are on occasion reducing concentration (Britain). In Europe there is a strong move towards vertical disintegration, while in the US there is none: however deregulation in the US may make for some further horizontal concentration.

In the area of technology, it is no longer clear that the largest unit sizes are automatically the cheapest: economies of scale in established plant types are not absent, but appear weaker than once seemed true. Meanwhile new technologies like fluidised beds and combined cycles at present offer power competitively at quite small sizes. They may in time however prove to have economic advantage at larger sizes. Among the older-established technologies, super-critical fossil technology never really established itself, and nuclear power, weighed down by cost pressures and public disapproval, is at best dormant as a new source. There is great diversity in technical choice: some countries such as the US specialising in newer small-scale technology; others like France keeping faith with large traditional units; while others, like Japan, are riding both horses. It is clear that a combination of high interest rates and a more 'commercial' approach to electricity investment (ie higher discount rates irrespective of interest rate levels) is both depressing total volumes of investment, and skewing investment choices towards quick-return projects with low capital intensity and high fuel use. In time this is likely to lead to a higher electricity price trajectory than traditional choices.

Electricity conservation offers significant scope for substantial expansion on technological and economic grounds, having been neglected in favour of other energy conservation policies in the past. The evidence is, however, that conservation, especially in the industrial sector, depends on capabilities and policies that go well beyond the scope of narrowly energy saving policies into the area of general technological capability.

In the the environmental area it is now clear that a wide range of environmental considerations deeply affect new technology and fuel choices, and increasingly affect the operation of existing systems. Regulation is

becoming a major issue in environment as in the economic sphere mentioned above, and overall regulatory capability in both areas is a significant issue. However, the diversity of both environmental issues and of individual national responses to them needs emphasis. A major question is the extent to which technological responses to environmental issues will mainly involve 'bolt-on' solutions or whether they will (as seems more likely) increasingly involve a degree of inherency and thus reduce choices. It is also not clear whether the thrust of industrialised country policies will lead to the cleaner use of 'dirty' fuels in the North, or will mainly emphasise the use of cleaner fuels. Finally, and most imponderably, there is the global warming issue: it is difficult to foresee its impact yet, but it is likely to have profound implications for energy conservation, for the choice of new technology and for the operation of existing systems.

4. AFRICA

4.1 General Description

Africa is the poorest region of the developing world; although GDP per capita varies substantially among sub-regions, it does not exceed \$700 in any sub-region. Moreover, the expected economic and social future for Africa is not promising. Population growth rates will remain among the highest in the world at over 3% at least until the end of this century, and will decrease to 2.8% thereafter only on the assumption that strong measures are taken now to reduce birth rates. Conversely, economic growth is expected to be relatively low until the end of this century, with annual levels of about 5% being achieved only on the basis of optimistic assumptions about aid that Africa will receive to finance investment and alleviate its foreign debt. If this scenario is correct, there will be no substantial increase in per capita GDP in the foreseeable future. These trends must raise serious doubts about the political and social stability of many parts of the continent, particularly as urbanisation rates are likely to increase.

This gloomy scenario contrasts drastically with the perspectives of the 60's. Indeed, it was then believed that large unexploited natural resources (especially energy) could offer a driving force for Africa's economic development. At the beginning of the 1970's, GDP growth in countries such as Zaire was derived mainly from mining and this substantially increased their per capita GDP. Even countries like Mali and Senegal, without large mineral resources, experienced GDP growth that was supported by agriculture and was large enough to sustain increases in per capita GDP.

However, in the 1970's the world economy went through radical changes that strongly reduced the inflow of capital and technology to African countries. This coincided with adverse climatic conditions in some countries (Senegal, Mali and Ivory Coast for instance) and war, rebellion or ethnic conflicts in others. The fragile African economies were unable to cope with these dramatic changes; they have since lost any dynamism they once had. Indeed, mining activity has been reduced and the price of

minerals has plunged; agricultural surpluses have fallen and prices of tradeable agricultural products slumped. Exports earnings fell, forcing substantial cuts in both imports and investment. Policies adopted to avoid recession led to rapid increases in both external debts and the share of public expenditure in GDP. Eventually, the combination of dramatic changes in the external world and the weaknesses of domestic policies induced an economic stagnation which in turn progressively reduced African countries' per capita GDP.

The profound economic, social and political crisis produced by these trends induced a review by international lending organisations of economic strategies for African countries. African governments, facing unpayable external debts and in desperate need for continuous inflow of capital and technology, are in no position to resist a direct involvement of international organisations in their economic policy making process. Comprehensive programmes of economic and institutional restructuring are taking place in several African countries under the leadership of the IMF.

A fierce controversy has emerged over the results of these programmes, some arguing that the results so far are not encouraging. It seems, however, that there is agreement on two main points: first that substantial debt relief is a pre-condition for any strategy for economic growth in Africa; and second that the role of the public sector in development strategy must be reviewed.

In any circumstances, it is difficult to predict Africa's economic and social trends, which will largely depend both on the amount of aid provided by industrial countries and on the level of success that African governments have in restructuring their economies. Current policies for the electricity sector in Africa must be analysed in this context.

4.2 Institutional Structure

Large indivisibilities are a central feature of energy projects and this has profound implications for the decision making process. Indeed, energy projects often produce economic effects that are far from marginal. This is especially true for the embryonic African economies where large

parts of the population have no access to modern energy sources, particularly electricity, and where severe financial and economic constraints prevent any chance of universal supply in the foreseeable future. Policy makers are therefore confronted with the complex political issue of providing the benefits of electricity supply for some regions and social groups, while others will go without.

The institutional framework determining energy policies in African countries reflects this situation. Several ministries and agencies are usually involved but have conflicting objectives. To improve the coherence of energy policies in practice, National Energy Commissions have recently been created in some countries (Zaire and Ivory Coast for instance); this is usually a direct response to recommendations from international organisations. These Commissions are likely to promote close coordination of energy policies, thereby increasing their effectiveness.

The electricity supply industry in Africa is usually managed by public monopolies which are perceived both by consumers and governments to be providing a public service.⁽¹⁾ They have little independence from government as far as investment, pricing and electrification policies are concerned; these issues are decided by the relevant government departments (often using the advice of external consulting firms) in consultation with the utilities' management. The criteria used for decision making tend to be strongly influenced by the goals of socio-economic development, but these are frequently in conflict with the realities of utilities' financial and economic positions. Obviously this situation is a source of tension between governments, utilities and financial institutions; these institutions frequently blame government interference in management decisions for the financial problems utilities are facing.

The infra-structure of the electricity supply industry in Africa is largely underdeveloped. There is rarely a grid covering all the major load centres or integrating the main power stations; supply is unreliable and consequently many industrial consumers produce their own power. There are a large number of these self-generators, some of which also provide electricity directly to other consumers, thereby partly filling a gap where public utilities are not able to supply.

Basically, it is possible to distinguish between two types of supply system:

- a. small interconnected grids covering the region surrounding the capital city plus a few relatively large power plants serving regional areas, and many small diesel engines supplying isolated centres.
- b. Several sub-regional grids with many diesel engines supplying isolated centres.

4.3 Trends in Electricity Demand

Africa accounts for only a small share of the developing world's industrial output (3.8%) and GDP (5.6%), despite a much higher population share (12.3%). Unsurprisingly, its share of modern energy consumption is small both in absolute terms and per capita (3.3%).

Oil products dominate African's consumption of modern energy sources (77.9%); electricity and coal both play a secondary role in the energy balance while natural gas is a tiny fraction (almost all in Nigeria). Africa is still however a large consumer of traditional fuels; its consumption of modern energy sources is estimated to be no more than 20% of its total final energy consumption.

Until the 1970's, energy policies in Africa were mainly designed to support trade and industrial growth. Indeed, many hydropower plants were built specifically to supply mining and metal producing plants. Energy consumption both per capita and per unit of GDP increased substantially during this early period as a result of economic growth, industrial activity and urbanisation. The flow of people to the cities led to particular pressure to supply electricity to household and service sectors.

In the 1980's, these trends changed radically; mining output was reduced and GDP stagnated. This resulted in a dramatic slow down in energy consumption growth rates. But population growth continued, producing a considerable reduction in per capita energy consumption while energy consumption per unit of GDP still increased.

Despite a substantial slowdown in industrial sector's consumption, electricity use did not lose momentum completely. Our country studies show that electricity consumption by urban households and services are still increasing quite rapidly. Policies to extend access to electricity for an increasing share of the population are pushing up electricity consumption and preventing any large reduction in total electricity consumption.

Within the African region, almost 80% of both modern energy sources and electricity consumption is concentrated in Nigeria, SADCC and Centre-East countries. There are large differences in consumption of modern energy sources per capita and per unit of GDP between countries and sub-regions. These differences are linked to the domestic availability of energy resources. Nigeria and SADCC have the most energy resources and are the largest consumers of energy as well, using three to four times more than the Sahelian countries. However, even their consumption is several times lower than that in any other developing region.

There are large uncertainties as far as future energy and electricity consumption is concerned. Although the actual demand will be greatly affected by the levels of economic growth achieved, high rates of population growth (3.7% a year to 2000 and 2.6% to 2025) are also likely to exert enormous pressure on demand, particularly if there is no slowing down in urbanisation. Our country studies indicate that the optimistic forecasts for electricity consumption growth of 7% to 10% a year - still frequent at the beginning of the 1980's - have now been revised downwards. Current consumption growth rates are close to population growth rates or rather lower. It seems that a gloomy scenario of no substantial increase in foreign investment and little or no success in restructuring economic policies is becoming more widely accepted. Under such circumstances, there is little hope that Africans will be able to obtain a substantial increase in per capita electricity consumption in the foreseeable future. Furthermore, these forecasts mean that most of the urban and rural African population will remain without access to electricity until the year 2000 at least.

4.4 Trends in Electricity Supply

African energy resources are poorly defined, except for hydro-resources, which have been largely identified although not completely evaluated. Fossil fuel resources remain largely untapped; less than 20% of

the sedimentary basins (9 million km²) is currently under exploration; the boom in exploration induced by the oil crisis had only a marginal effect and then largely in oil exporting countries. Despite this lack of knowledge, fossil fuel reserves are many times larger than production, and known hydro resources could easily meet all electricity demand for the foreseeable future.

But even if the total resource is adequate, it is worth noting that African energy resources, although relatively large, are not evenly distributed across the regions. Nigeria (which accounts for most of the known oil and gas reserves), Centre-East (with much of the hydro resources) and SADCC are rich enough in energy resources to remain net energy exporters for many years to come. In the Sahel-West, Sahel-East and Atlantic Coast, fossil fuel resources are limited; these sub-regions are likely to remain net energy importers, although unexploited hydro-resources offer an opportunity to substantially reduce fossil fuel imports for much of their electricity supply.

Africa's production of modern energy sources apart from oil is modest. Oil's share of total modern energy production is over 90% but oil is mainly exported. In fact, domestic markets are as yet very small; only Nigeria and Kenya have oil consumption over 1 million tonnes/year and only 8 countries have electricity consumption higher than 1Twh. These small markets greatly limit the development of hydro, natural gas and coal resources, which cannot be easily exported for technical and economic reasons. By contrast, there have been few difficulties in developing the production of oil - which can be exported - as soon as reserves have been identified, especially in non-OPEC countries.

Production of modern energy sources increased substantially in the first half of the 1970's (10.9% a year), but slowed down in the second half (3.0% a year) and was reduced still further in the 1980's. These trends contrast with the continuous increase in consumption, and have reduced the exportable energy surplus of the region. Electricity production followed very similar trends; production increased steadily at very high rates of growth (9% a year) during the 1970's but declined in the 1980's. Three main reasons have contributed to this disastrous outcome: the economic crisis, armed conflicts in the SADCC region, and, in the case of electricity, the unexpectedly severe drought on the Atlantic coast which dramatically reduced the output of hydro-plants.

The main primary energy source used for electricity generation in the region is hydro. This situation largely results from a strategy adopted in the 1960's which obtained strong support from both multilateral and bilateral financial sources for hydro development. Large hydropower plants were built to supply an increasing demand and to foster industrial growth. Hydropower also contributed to the balance of payments by avoiding imports of oil, or increasing oil surplus for exports. The share of hydropower in the total installed generating capacity (19.7 Gw) was 67% in 1985.

Nigeria and the Western Sahel both supply a large proportion of their electricity from thermal plants. Nigeria is increasingly moving to thermal power plants to take advantage of its relatively large hydrocarbon resources, while Sahel-West has limited hydro resources. Thermal power plants are mainly fuelled with oil products; natural gas fuelled power stations are currently under construction in Nigeria, and coal use in the SADCC region is concentrated in Zimbabwe and Botswana. Many diesel power plants are used to supply areas not connected to the grids.

Currently, 8 hydropower plants (with a total capacity of 500 Mw) are under construction and another 4 are currently under review (900 Mw). These levels indicate a substantial slowdown in the construction of hydropower stations; in fact most new investment is concentrated on the rehabilitation of old power stations, particularly thermal plants. If these trends away from hydro continue, the use of fossil fuels (particularly oil products) in electricity generation is likely to increase quickly even under a scenario in which there is a slow increase in per capita electricity consumption. This will have a substantial long term impact on the trade balance.

4.5 Key Issues

A. Electrification

There are huge opportunities to improve the productivity of the African ESIs. These result mainly from their situation of major underdevelopment. Electricity supply is largely limited to a small

proportion of the urban population; there is little interconnection between domestic networks; many old, highly inefficient diesel plants are used to supply isolated, small load centres; extension of the rural electrification network has practically ceased; capacity and availability factors of power plants are very low. But these opportunities are not easy to capture. Actions will be required across a wide spectrum to build up the human capacities to operate, maintain and manage the systems, and to maintain adequate flows of local and foreign finance.

The strategic challenge facing African ESIs is to extend electricity supply to a larger share of the population. In Zaire and Mali, for instance, only a small part of the capital is supplied with electricity (Kinshasa 20% and Bamako 30%). The situation is obviously worse in other towns and there is almost no supply at all in rural areas. The situation is better in Senegal where 83% of the population of Dakar and over 43% of the population in the larger towns are supplied with electricity. But the situation is still very difficult outside the major towns.

The Ivory Coast is an exception; here the national grid supplies most of the urban population and a large share of the rural areas (55%) as well. Nevertheless, a very high rate of population growth, especially in urban areas, keeps up the pressure to extend the distribution network to new consumers.

Increasing the density of consumption within supply networks in African countries is strongly limited by both the inability of consumers to pay and the low consumption levels of the low income groups. Low densities increase supply costs, diminishing still further the number of consumers who are able to pay, and the consumption of those that can afford to pay. This situation generates a vicious circle that can only be changed by offering subsidies for electricity to low income groups. Such a policy has political benefits since it reduces social problems especially in urban areas; arguably it has beneficial effects since electricity is an essential input for economic development. There are potential economic and financial difficulties here, but the issues are not whether or not to have subsidies; they are first, would the subsidy have a greater beneficial effect if spent on other activities; and second, how can the subsidy be financed without compromising the financial viability of the ESI or central government? This is especially problematic for African utilities, which are already in severe financial crisis.

Although urbanisation and population growth are together exerting an increasing pressure on electricity consumption, industry is still the main driving force that can increase electricity demand substantially. Historically, industrial growth justified the construction of the large power plants, particularly hydro, that reduced supply costs. Moreover, industrial growth increased income, which in turn raised the ability of people to pay for electricity supplies; both movements improved ESIs' productivity substantially.

A scenario of low industrial growth is likely to limit electricity consumption to a few in large towns. In these circumstances, the scope for large improvements in productivity through new construction will obviously be much more limited. Opportunities for increasing productivity will have to be sought elsewhere. Our case studies indicate that interconnection both nationally and internationally may offer the largest source of productivity improvements for African ESIs. A recent study from EDF pointed out that there are likely to be substantial economic benefits from the interconnection of Dakar with its two main regional networks; capacity factor would be increased and old, inefficient diesel power stations could be closed down. These benefits would increase further if there were interconnections with neighbouring countries; in this case, Senegal could substitute relatively inexpensive hydro-generated electricity for expensive thermally-generated power. These results confirm those of another study for the African Development Bank which shows that the interconnection of the Atlantic Coast countries would make possible optimum development of regional hydropower resources, reducing the costs of both electricity supply and of power plant investment. Eventually, the reliability of the ESI in all countries involved would increase. This would particularly benefit industrial consumers, who could then eliminate self-generating capacity.

For very poor countries such as Mali, which have small domestic market, interconnexion with neighbouring countries is perhaps the only opportunity to develop fully their hydro-resources, or to interconnect their domestic sub-systems in the foreseeable future. Extremely inefficient, unreliable, old diesel power stations cannot be retired until interconnection occurs. However, it is exactly these countries that lack

the financial and political leverage to get funding. Under the present economic climate, therefore, such projects are likely to be postponed indefinitely. The project to interconnect Mali-Senegal-Mauritania is typical; the Manatali dam is already built but political and financial difficulties are postponing the installation of turbines to generate electricity. The situation of Zaire is similar; the funds are not available to transmit the enormous hydropower resources already installed that could be a driving force for improvements in the entire centre of Africa. The existing interconnections with neighbouring countries are limited to small links with the Congo, Rwanda and Burundi.

B. Technology

Rehabilitation of old power plants, particularly diesel stations, can be another source of productivity improvement, although the actual experience in some countries like Mali is that in many cases replacement is the rational decision. The financial crisis faced by both utilities and governments has had profound effects on investments. Financial difficulties have obliged utilities to postpone crucial projects that would increase supply capacity and reinforce the transmission/distribution network. The consequences have been two-fold; first, aged, inefficient power plants that otherwise would only be used as reserve capacity, are simply not closed down and are generating electricity on a regular basis. Second, there are many cases where generating capacity is not in balance with the actual transmission and distribution infrastructure. In some countries, like Zaire, the ludicrous situation arises where nominal over-capacity in generation simultaneously co-exists with consumer rationing; in the Ivory Coast, the hydropower plant of Buyo has 165Mw of installed capacity but the transmission line can only carry 100 Mw. The prospects of very limited financial resources in the foreseeable future obviously generates strong incentives for a rehabilitation programme, particularly of transmission/distribution lines in those countries with a generating capacity surplus.

Efficiency is an issue that has received insufficient attention in most African countries, on both the demand and the supply side. On the supply side, the idea that modern hydropower plants would sooner or later replace the old thermal power plants can possibly explain the neglect. But

this long standing problem was certainly intensified by poor management and maintenance practices which accompanied the financial crisis. In Mali and Senegal, for instance, thermal power plants, particularly small diesel stations, use very large amounts of fuel per unit of electricity produced. But the situation of hydropower plants is not much better; indeed, a severe drought at the beginning of the 1980's was poorly managed in Ivory Coast resulting in enormous problems for electricity supply that still remain. Moreover, very high distribution losses and poor service are frequent (these are often blamed on unofficial and uncontrollable connections, but are likely to be largely the result of bad management and maintenance practices). Ivory Coast is again the exception with reasonably low losses and a good quality of service.

From the demand side, low levels of consumption may seem to imply that there are no opportunities for conservation. This seems not to be the case however; a study of the potential for electricity conservation in Senegal identified large opportunities, especially in public buildings and hospitals; another study in the Ivory Coast suggested that a saving in electricity consumption of 12% in industry could be achieved with more appropriate policies.

C. Finance and Pricing

The financial situation of African utilities is very poor; 16 utilities out of 27 are operating at a loss. This situation results from a combination of both domestic and international factors. The oil crisis and subsequently the debt crisis have both had strong impacts on African economies, especially on the electricity supply industry.

First, economic growth slowed down rapidly, resulting in substantial but unexpected cuts in electricity consumption growth; consequently generating capacity that had been ordered in the past on the assumption of sustained increase in demand resulted when it came on stream, in substantial overcapacity. While the terrible situation facing the Inga power plant in Zaire is perhaps the saddest illustration of this sort of problem, there are many other less well known cases. The Inga Plant still uses only 20% of installed capacity some 4 years after construction.

Second, reduction in the flow of private capital, combined with a decline in the terms of trade, resulted in a sharp deterioration in current balance of payment accounts of many African countries. They were forced to undertake large devaluations of their currencies; utilities that were heavily indebted in foreign currencies were faced with enormous increases in their financial costs. This in turn was exacerbated by the increase in interest rates to unprecedented levels. For instance, in the case of Energie Electrique de la Cote d'Ivoire, despite an increase of 36.9% in real electricity prices, the proportion of revenues required to pay financial charges rose from 12.3% in 1982 to 21.4% in 1987.

Third, the slowdown in economic growth and the sharp changes in the international financial and trade markets have compelled African countries to introduce harsh economic policies and to become more dependent on foreign aid. Possibly on the assumption that industrial countries would eventually recognise their responsibilities for the financial and economic crisis, many African countries opted to introduce moderate adjustment policies that were more easily accepted both politically and socially. Tragically, the required levels of aid were not provided and the treasuries of most African countries were technically bankrupted. In these circumstances, it is perhaps not surprising that public services and government agencies are consistently not paying their electricity bills. For instance, the consumers of SENELEC in Senegal and EDM in Mali (including government consumers) owe these utilities the equivalent of 4.4 and 12.7 months' supply, respectively.

In some countries, such as Ivory Coast, severe drought for a number of years has reduced the performance of hydropower plants and necessitated the unplanned construction of additional thermal power plants. Utilities that were facing substantial increases in electricity costs therefore had to pay yet another burden. Massive increases in electricity prices were inevitable but for political and social reasons, they tended to be postponed for many years. Recently, average prices have risen enormously in real terms in all the countries we have studied; moreover, the marginal cost pricing approach was introduced in some countries to reduce price distortions between the costs of supply and revenues. But price distortions among regions within each country still remain as prices are commonly equalized across whole countries as part of regional development policies and to contribute to regional equity.

Average electricity prices remain below average costs almost everywhere in Africa. This situation can be largely explained by the extremely unbalanced structure of electricity supply in these countries. While the capital and major towns are supplied with relatively inexpensive electricity, mainly from hydropower plants, the rest of the country is supplied with quite expensive electricity, generated in old, inefficient diesel stations. In Mali for instance, electricity costs in isolated areas are ten times the electricity costs in Bamako. Frequently, electricity prices in isolated areas do not cover even the fuel costs. A similar situation obliged SNEL to ration electricity supply in isolated areas of Zaire to reduce financial losses (rather than raise prices to rural consumers).

This complex situation puts policy makers in a difficult position; either prices are enormously increased in isolated areas to reflect costs or subsidies must be given. It is possible to argue that the long run marginal cost in most isolated areas is much lower than current costs if it is assumed that the grid is to be extended to supply such areas; therefore, subsidies are transient and should reasonably be maintained to enhance economic growth. However, Treasuries of most African countries are in no position to pay such subsidies; other electricity consumers could subsidise isolated consumers but it is possible that such a cost will reduce competitiveness, particularly for tradeable product producers. Facing such a complex issue, politicians tended to adopt the easiest solution; they keep prices in isolated areas below actual costs but do not provide subsidies to utilities either directly, or indirectly (by allowing cross-subsidisation). The utilities therefore inevitably run at a financial loss.

Such a combination of deteriorating domestic and international forces has dramatically changed the economic performance of African utilities. Their self-financing ratio was reduced from 25% in the end of the 1960's to 17% in the beginning of the 1980's; large debts were accumulated that cannot possibly be serviced without either substantial debt relief or more massive electricity price increases. As far as the future is concerned, some utilities envisage self financing ratios close to those of the 1960's in their best scenario while others (Mali for instance) can not imagine financing more than 5%. African governments can hardly fill the gap

themselves; therefore if the flow of foreign public capital to Africa is not increased, it is quite likely that the rate of growth of African ESI will be very low indeed - in some cases possibly lower than population growth rates.

The financial crisis places management of African utilities under considerable political pressure. Shortage of financial resources has obliged governments to review planned investments. Cuts were quite often decided without consulting utilities; cost escalations were also mainly outside the control of utilities but were politically difficult to pass on to consumers. In practice, the decision and even the implementation of electricity projects in countries like Senegal was undertaken outside utilities.

In brief, the scope for rational management decision making was severely reduced by the financial crisis. This situation can possibly explain much of the poor performance of utilities in the 1970's and 1980's. However, it is naive to imagine that political issues can be avoided in decisions concerning the ESI, although it is reasonable to imagine that management should be free to conduct its own affairs once the political ground for decision-making has been settled. In order to achieve this separation of government policy from day to day management of utilities, a few African countries have introduced "contrat-plan", whereby government fixes macro-economic and political goals for utilities but allows their management freedom to make decisions within their framework.

It remains true, however, that the managements of African utilities were, and still are, badly prepared for the uncertain environment that ESIs have had to face since the 1970's and are likely to face in the foreseeable future. Indeed, management of African utilities still relies heavily on occasional, external expertise to decide on issues such as demand forecasting and project appraisal. External experts confronted with the lack of data to feed their planning tools tend either to use rudimentary methods or, worse, to "produce" the data they need to feed sophisticated models; both solutions obviously provide poor results. Moreover, management is frequently confronted with contradictory advice from different groups of experts but does not have the capacity to decide between them. Training of African utilities' management needs to be

enhanced in several areas such as the planning of supply and demand in conditions of large uncertainties; assessment of macro-impacts of electricity supply projects; pricing; maintenance and rehabilitation; user's capability; technological choice, etc.

FOOTNOTES

1. It is worth remarking that in many African countries, the electricity utilities are also responsible for water management.

CHAPTER 5 ASIA

5.1 General Description

We have, for all the sections of this chapter, divided Asia into three main regions: Northeast and Southeast, China and South Asia. These regions are so different from each other, and contain such large populations, that they clearly deserve separate treatment.

A. Northeast and Southeast Asia

This region comprises Northeast and Southeast Asia, including Indochina and Burma. The Northeast Asian region is composed of Hong Kong, Taiwan and South Korea, and the Southeast Asia region includes member countries of the Association of Southeast Asian Nations (ASEAN), viz., Indonesia, Malaysia, the Philippines, Singapore, Thailand and Brunei, Burma, plus Indochina which includes Vietnam, Laos and Cambodia.

The region has a combined population of more than 480 million. Indonesia accounts for the largest share - 170 million or 35.4 percent, and Brunei has the smallest population (230,000).

With the exception of the Northeast Asian countries, Brunei and Singapore, a large proportion (over 60 percent) of the population in the region still lives in the rural areas, and more than 40 percent of the labour force continues to depend on agriculture for employment. Urbanisation has been relatively slow, particularly in the economically-depressed countries of Indochina.

The combined GDP (1980 prices) for the region was US\$775.4 billion in 1986, averaging US\$1,630 per capita. However, there is a wide variation in the average incomes of countries in the region. The Northeast Asian countries, which globally account for about 38 percent of the combined GDP, have the highest per capita incomes (US\$4,486), followed by the Southeast Asian countries (US\$1,514) and the Indochinese states plus Burma which have

a GDP of only US\$249 per capita. Since 1970, real GDP growth has been fairly rapid for the region as a whole except for Indochina. Northeast Asia posted an average growth rate of 8.5 percent for the period 1970-1986 while Southeast Asia grew by an average of 2.9 percent annually. There was a marked slowdown in the economies of these countries during the 1980's but towards the end of the 1980's the economic situation of most of the countries in the region has improved, especially those of Thailand and Malaysia, which started to show dynamic growth.

Despite the economic performance of the majority of the countries in the region, most of the people are still poor. More than 50 percent, (or over 70 percent including Indochina and Burma) continue to live with less than one US dollar per day. Furthermore, the gap between urban and rural development is widening, which raises the question of whether the current economic growth process is sustainable.

However, the outlook for the region as a whole is promising. The Newly Industrialised Countries (NICs), especially South Korea and Taiwan will continue to post significant growth rates, albeit less spectacular than during the last decades. Thailand and Malaysia, two of the resource-rich ASEAN countries, will become more industrialized with a particularly dynamic export oriented manufacturing sector. As a whole, the region will probably experience a rapid process of economic growth.

B. China

China has a population of over 1 billion people (1,081 million in 1987) of which over half are in rural areas. It has a total energy consumption of 739.2 million TCE in 1985, some used 60% in industry, 23% in households, 10% in services and 7% in agriculture.

The electricity sector is of crucial significance to the future of Chinese economic development. While there are difficulties in all energy areas, shortages of electricity are acute and are considered to be the dominant bottleneck in China's economic development. This is despite a doubling in both electricity capacity and generation in the ten years to 1988. The extent of shortages can be gauged from the fact that while installed capacity had reached 112.9 Gw in 1988, the capacity of power driven equipment amounted to 290 Gw.

C. South Asia

The South Asian region comprises seven developing countries: Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. They had a combined population of over a billion people (1,019 million in 1987). These nations are at various stages of economic development, and are very diverse in terms of their geographical area, population level, and indigenous energy resource endowments etc. Per capita GDP ranges from \$138 for Nepal to \$375 for Sri Lanka. Although more than 80% of the population is in the rural areas, India alone has a purchasing power larger than the Federal Republic of Germany.

Some of the countries of the region, notably India, Pakistan and Sri Lanka have a thriving modern sector, some parts of which have similar structures and growth prospects to other Asian NICs. The economic prospects are therefore good, though much depends on the absence of natural disaster and political stability.

5.2 Institutional Structure

A. Northeast and Southeast Asia

The government plays a dominant role in the energy sector and the electricity subsector of the countries of the region. The degree of involvement, however, varies from one country to another. In most countries, overall energy planning is done within a central agency which is responsible for coordinating and preparing the country's energy plan. Policy issues related to pricing and investments are usually tackled by an inter-ministerial body, due to the wide-ranging social impact of decisions made on these matters.

The power sector in most countries is a state monopoly enterprise whose responsibilities include generation, transmission, and distribution (i.e. vertical integration). Traditionally, private companies were allowed to sell their excess electricity to surrounding areas which are generally inaccessible and uneconomical to connect with the main grid. More recently, however, private participation in the power sector is being considered as a

way of easing the pressure on governments' financial resources and debt-servicing capacity. Private power through cogeneration is also being encouraged to reduce system peak load, improve system efficiency, and reduce the marginal cost of building new plants to meet peaking requirements.

In countries where the private sector plays a major role in the electricity subsector, organizational deficiencies, e.g. lack of reporting relationships between organisations responsible for the monitoring work have been observed. Shortages of technical expertise in certain areas have also been experienced and limited attention is generally given to system planning. In these countries, the progress of electrification has been slow and most utilities suffer from poor financial performance.

Fragmentation usually results in the poor performance of electric utilities. In Indochina, responsibilities for energy planning and management are divided among various government bodies, leading to delays in project implementation. The absence of a comprehensive energy plan has also been a major cause of power shortages. In these countries, a weak statistical base has hampered the development of adequate methodologies for projecting demand for energy and electricity for use in planning.

In countries where separate entities are exploiting the energy resource and generating electricity, e.g. Philippine National Oil Co. and National Power Corporation in the Philippines, and Petroleum Authority and Electricity Generating Authority in Thailand, some problems of coordination and pricing also arise which affect future energy supplies and the choice of technology.

B. China

All Chinese power plants are state-owned, but there are three kinds of institution involved in electricity supply: national utilities, local utilities and self-generation. In 1986, the capacity shares of these three types were 76.9%, 14.4% and 8.7% respectively. Since the economic reforms initiated in 1978, China has encouraged foreign investment in power plant, and foreign participation now amounts to over \$4 billion, covering 17 Gw of new capacity. In the last ten years, the role of the State Planning

Commission in all investment sectors has been declining, and since 1986 local governments and enterprises have begun to play a dominant role in both plant construction and operation. Since 1988, there has been a deliberate encouragement to expanded self-generation.

C. South Asia

Other than in India and Pakistan, there is in this region usually one 'apex' utility which is responsible for planning, construction and operation of power generation, transmission and distribution facilities covering more-or-less all the parts of the country (directly or indirectly) that are served by public electric utilities. There may be other distribution agencies which purchase power in bulk from this apex body for distribution to rural or other local areas (for instance, in Bangladesh and Sri Lanka). In Pakistan, there are two major utilities which serve the Karachi area and other parts of the country. In India, there are several utilities publicly owned at the state level as well as other generation corporations at the central level, which are responsible for various aspects of power system planning and operation. There are also three privately-owned utilities in India.

Despite the planning and massive resource investments in the power sector systems of the various countries, power shortages continue. Many industrial and commercial establishments have responded by investing in standby/captive generation facilities. This is, from a governmental point of view, an unplanned expansion of generating facilities, a consequence of independent decisions made by private entrepreneurs and electricity consumers, and of the expectation that power shortages will continue in the foreseeable future. Nevertheless, this phenomenon clearly demonstrates that substantial private capital is available for power generation. However, the role of the private sector in participating in the organised public electricity supply sector has varied widely from country to country and has been influenced largely by administrative and legislative considerations.

For instance, in Pakistan, the Government encourages private sector investment in generation facilities to augment the flow of resources to the sector. In September 1985, the Economic Coordination Committee of the

cabinet approved a charter of terms and conditions under which the private sector would be invited to participate in power generation within the framework of medium- and long-term plans. A National Deregulation Commission, which was appointed in August 1985, also studied the possibilities for private sector participation in power distribution.

However, in India, the Electricity Supply Act stipulates that a private electricity consumer can generate power only for his own use, and that only after obtaining a formal sanction from the relevant electric power utility in the respective state or union territory. The Act does not allow for the private sector, in general, both to generate power and supply other consumers. This has hampered the growth of cogeneration facilities in various industries, the pooling of financial resources from more than one industry to set up a large scale power generating unit, and (to some extent in recent years) investment by industry in renewable energy technologies such as wind systems. The Electricity Act would need to be amended and suitably modified, and other modalities worked out, before the private sector can participate to any significant extent in the organized power supply system in India.

5.3 Trends in Electricity Demand

A. Northeast and Southeast Asia

Electricity is the fastest growing fuel in the region, far exceeding the growth of total commercial energy in all countries. Its share in total commercial energy consumption has increased significantly over the years. In Northeast Asia, electricity now accounts for about 25 percent of total commercial energy consumption. In Southeast Asia, the share of electricity to total commercial energy has grown from about 8 percent in 1970 to about 15 percent in 1987. In Indochina, where traditional energy fuels provide over 75 percent of total energy supplies, electricity accounts for a small but increasing share of total energy.

Between 1970 and 1986, electricity consumption for the region as a whole grew at annual average rate of 10.4 percent. In the sub-regions of Northeast and Southeast Asia, electricity consumption increased by more

than 10 percent annually. This rapid growth in demand was brought about by dynamic changes in the economies of Northeast and Southeast Asia. GDP growth in Northeast and Southeast Asia averaged 8.5 percent and 5.9 percent annually during the period, with industry, and in particular the manufacturing sector, contributing an increasing share of total output.

Electricity consumption in Indochina grew at more modest rates. Vietnam and Burma posted average growth rates of 5.7 percent and 6.8 percent annually during the period 1971 - 1985. The extension of transmission and distribution facilities to other provinces, introduction of electrification programmes, and improved economic activities in Laos since 1980 have increased domestic demand for electricity by about 11 percent per year. Electricity consumption in Cambodia was more or less stable during the 1970's but dropped drastically during the 1980's because of the war.

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The average per capita electricity consumption of countries in the region varies widely. Per capita electricity consumption is highest in Brunei (4,585 kWh in 1986), followed by Singapore (3,250 kWh), Hong Kong (3,096 kWh), Taiwan (2,463 kWh) and South Korea (1,481 kWh). Average per capita electricity consumption in Indochina, meanwhile, amounts to less than 100 kWh, with Cambodia (8 kWh) having the least.

For most of the countries in the region, growth in consumption of energy and electricity slowed down in the 1980's compared to the 1970's. This trend in demand followed closely the pattern of growth in economic output in the region and partly reflected the response of customers to major adjustments in the domestic prices of petroleum and electricity in the late 1970's and early 1980's. Indonesia was the only country in Southeast Asia whose consumption of electricity picked up in the 1980's due to more aggressive electrification programs and major investments made in heavy and light manufacturing industries during the country's third plan (Repelita III).

Among the different sectors, industry showed the largest decline. The growth in industrial electricity consumption in Northeast and Southeast Asia dropped to an average of 6.4 percent during the 1980's compared to 13.2 percent in the 1970's. The slowdown was particularly marked in the

export-oriented market economies of Taiwan, South Korea, Hong Kong, and Singapore whose industrial output were adversely affected by the slowdown in trade due to recession and increased protectionism in the West.

As a proportion of total electricity consumption, the share of industry has declined while that of the domestic sector has increased due to improvements in the living standards of the population and the expansion of rural electrification. In the newly-industrializing countries of Taiwan, South Korea, Hong Kong and Singapore, the share of the commercial sector in total electricity consumption has also increased due to a rise in the use of electricity for space cooling and an expansion of the services industry.

Energy conservation has lost its momentum in the countries of the region. Conservation has been made less urgent by the softening of international oil prices and the discovery of adequate domestic energy resources. In most countries, however, incentives for efficient energy use, e.g. accelerated depreciation and tax credits for manufacturers of energy saving equipment, continue to be offered. Measures which have been established earlier to discourage wasteful use of energy such as road taxes have largely remained unchanged. Research and development (R&D) activities for new energy technologies and more efficient production processes continue to be undertaken and energy audits of large firms are still being conducted regularly.

Future electricity demand in the region will remain strong but is expected to slow down compared to the 1970's and 1980's, primarily because of the slackening of demand in Northeast Asia. Electricity demand in Northeast Asia is forecast to grow by an average of 6.0 percent annually up to the year 2000, lower than the historical average growth rate of 9.7 percent. Electricity demand in Southeast Asia is expected to grow by a slightly higher rate of 9.1 percent due to a more optimistic economic outlook and an expanded electrification coverage. Indonesia, for instance, expects electricity demand to grow by an average of 13.1 percent yearly from 1987 to 2000 because of much higher electrification targets in both urban and rural areas under the fifth Plan (Repelita V).

Indochina's electricity demand is projected to grow by about 10 percent annually up to the year 2000, the highest in the region. This rapid growth in demand is expected as countries in this sub-region

reconstruct their war-ravaged economies. Vietnam expects industrial consumption to increase rapidly because of greater emphasis placed on small and medium industries. Laos forecasts consumption in the agriculture sector to speed up with the increase in pumped irrigation facilities, while Burma expects total consumption to grow rapidly with the interconnection of the three existing grids and the rehabilitation and expansion of transmission and distribution lines.

B. China

Electricity consumption has increased during recent years; in 1985, net consumption was 381.3 TWh (93% of the gross power generated). Of this, 75% was in industry, 11% in Agriculture, 8% in Services, and 6% in Households. Per capita consumption of electricity was 460 KWh (1987).

Electricity growth has been highest in light industry (8.9% annually since 1980) as compared with a growth of 5.6% in heavy industry. This is a result of government policy to develop agriculture and light industry in preference to heavy industry.

Electricity use in households has been under emphasised over many years. Households and services accounted for 24% of power use in 1949 but this had dropped to about 5% by 1976. By 1986 household consumption was about 5% of total electricity use at 23kwh per capita. (16kwh in rural areas and 57.6 kwh in cities.) It seems likely that there is a huge suppressed demand for electricity by households. The use of electrical appliances has increased; particularly fans (103.9 per 100 households). Nearly 20% of households had refrigerators in 1987 while almost none owned refrigerators in 1980.

C. South Asia

Although the consumption of electricity has increased rapidly during the past decade or so, it is important to note that significant supply constraints still exist. It is not only that the consumption by the consumers who are already connected to the utility supplies would increase if there were no shortages, but also that there is a long waiting list of potential consumers wanting a connection. This means that trends in

electricity use may be a serious underestimate of market demand. New connections have been largely influenced by investment levels and resource availability and are seldom a reflection of demand. Moreover, as the economies expand and income levels rise, the consumption per residential consumer is also expected to rise because of increasing use of electric appliances. It is for such reasons that electricity sales are anticipated to continue to grow rapidly in the foreseeable future.

Per capita electricity consumption ranges from 33 KWh/capita in Bangladesh to 218 KWh/capita in Pakistan.

5.4 Trends in Electricity Supply

A. Northeast and Southeast Asia

The region as a whole is self-sufficient in energy and is, in fact, a net exporter. Intra-regional trade in various fuels and electricity has been growing. Oil and gas from Brunei, Malaysia, Indonesia and Burma are exported to some countries in the region, and so is coal from Vietnam, Malaysia and Indonesia. Electricity trade also plays an important role in Thailand, Laos, Malaysia and Singapore. Imbalances between demand and supply for specific products, however, still exist, necessitating imports from other regions of the world. This particularly so for oil; only Indonesia, Malaysia, Brunei and Burma produce oil in significant quantities. Most oil importers in the region continue to spend more than 30 percent of their export receipts on their oil bill.

Total electricity production increased by more than five times its level in 1970 to 302 TWh in 1987, representing an average growth rate of 10.5 percent during the period. Electricity production was fastest in Northeast Asia (11.3 percent per year), followed by Southeast Asia (10.0 percent) and Indochina (7.0 percent). Northeast Asia, which has two of the largest electricity producers in the developing world (South Korea and Taiwan), contributed 59.3 percent of the total while Southeast Asia and Indochina contributed 39.3 percent and 2.9 percent, respectively. The share of Northeast Asia has been increasing while the shares of Southeast Asia and Indochina have been declining. Total electricity production,

however, slowed down in the 1980's compared to the 1970's, reflecting closely the pattern of electricity demand.

Electricity generation from thermal power plants amounted to 187 Twh in 1987, or 61.9 percent of total electricity production in the region. The share of thermal power plants in total generation reached a peak of 87.7 percent in 1977 then gradually declined to 61.9 percent in 1987. Until the early 1980's, oil was the largest primary energy source for electricity production in the region. However, massive shifts towards coal and natural gas have reduced oil's share.

The deliberate move away from oil, even in countries with sufficient petroleum resources, has led to an increase in the use of other non-oil sources. In Northeast Asia, the share of nuclear has risen rapidly from 0.2 percent of electricity generated in 1977 to 41.4 percent in 1987. Geothermal has contributed a small but significant share of total electricity generated in Southeast Asia. Hydro's share in total electricity generated has declined in Northeast Asia but has increased in Indochina. Hydro's contribution in Southeast Asia has stabilized at around 20 percent.

The total installed generating capacity in the region in 1987 was 80,413 MW, of which 55,954 MW (69.6 percent) was thermal, 12,681 MW (15.8 percent) was hydro, 10,860 MW (13.5 percent) was nuclear, and 918 MW was geothermal. About one-third of thermal capacity was accounted for by coal and gas-fired plants. Since its introduction in 1977, nuclear capacity has grown rapidly and occupied 24.0 percent of installed capacity in Northeast Asia in 1987. The share of public utilities increased to about 89 percent of total installed capacity in the region while that of self-producers declined to about 11 percent.

South Korea has by far the largest capacity (20,982 MW), followed by Taiwan (17,589 MW), Indonesia (10,430 MW), and Thailand (7,801 MW). These same countries registered double-digit growth rates in capacity during 1970 - 1987, exceeding the 10.5 percent average growth rate for the region. Starting from a very low base, Laos posted the highest average growth rate in capacity (15.6 percent) in the region, but most of the electricity generated was exported to Thailand.

With the exception of nuclear fuel, the region as a whole has adequate energy resources on which to build additional capacity requirements. Future electricity production, therefore, should be able to meet the projected demand if the countries in the region are able to muster enough financial support and carry out the programmed projects without substantial delays.

Intra-regional trade in electricity is expected to increase with the planned reinforcement of transmission lines between Thailand and Malaysia, Thailand and Laos, and Malaysia and Singapore. Further expansion in electricity trade could be fostered through closer collaboration in the development of huge hydro resources among the riparian countries in the region.

The strategies of the countries in the region vary with respect to planned capacity additions, but all are aimed at reducing dependence on oil for power generation. This strategy of substituting out of oil is not only true for the net oil exporters in the region but also for countries without domestic alternatives such as Hong Kong and Singapore as well as countries in Indochina which were shielded from the effects of the oil crises in the 1970's. Within the next ten to fifteen years, oil-fired plants will either be retired or converted into dual-fired systems utilizing coal or natural gas. Small diesel units will continue to be set up only in areas which are generally inaccessible to the main grid.

The total installed generating capacity of the region is expected to double during the period 1988 - 2000. Aggregate capacity is forecast to grow by more than three times in Indochina and by more than twice in Southeast Asia. Northeast Asia's installed capacity, meanwhile, is expected to increase by about 70 percent. By the year 2000, total installed generating capacity in Southeast Asia is projected to almost equal the capacity in Northeast Asia, mainly because of the rapid increases in the installed capacities of Indonesia and Thailand.

Northeast Asia will continue in the direction of nuclear and coal. Hong Kong will join Taiwan and South Korea as users of nuclear power by commissioning its first nuclear power plant by 1991. The future electricity requirements of Southeast Asia will be met mainly by coal and

natural gas. However, hydro and geothermal could play much more important roles in the future if the interplay of politics and economics work in their favour. Malaysia, for instance, could have about 1,500 MW of power from the Bakun Hydro project which remains untapped. The Philippines is likewise faced with a choice of either exploiting the abundant coal resources in the North or utilizing the extensive geothermal resources in the Central region.

Indochina will continue to emphasise hydro development in its expansion programs. Coal plants in Vietnam and gas turbine plants in Burma are also planned for construction to supplement hydro capacity during the dry season. In addition to generation projects, Indochina places a lot of importance on the expansion and improvement of overloaded and often worn out transmission and distribution lines.

B. China

During the ten years from 1978 to 1988, China doubled its electricity generation and installed capacity. In 1988, generation reached 545 TWh (256 TWh in 1978) and installed capacity reached 115.5 GW (57.1 GW in 1978). The annual growth rate of generation and installed capacity was 7.8% and 7.3% respectively. In 1988, China had 296 thermal power units with capacities over 100 MW. The largest power plant, the Gezhouba hydro power plant was finished in 1988, and has an installed capacity of 2.715 GW.

Electricity generation has consistently accounted for about 23% of the country's total primary energy consumption throughout the 1980's, but unusually only 24% of coal consumption is accounted for by the power sector (this compares with 86% in the US and 74% in the UK). Nevertheless, within the electricity system, coal is the dominant fuel.

Interprovincial grids exist for North China, East China, Central China and the Northeast. These lines have a capacity of 500 KV or 220 KV. Each of the four grids has capacity over 14 GW and generation over 80 TWh.

Generally, almost all urban residents are regarded as being served with electricity; by 1985, however, 40% of rural residents were not served

with electricity. The government has made an effort to solve this problem, but it is unlikely that all counties will be supplied with grid electricity in the near future.

The growth of electricity use is expected to exceed the growth of GNP: and GNP is projected to quadruple between now and the year 2000. Various projections suggest an actual growth of annual electricity generated of 5.6% to 7.5%. If the higher target of approximately 1,200 TWh is achieved by 2000 some 90% of rural areas will have electricity and rural per capita consumption will be 200 kWh for both domestic and productive uses. Urban domestic use will rise from 25 kWh to 100 kWh per household.

In accordance with the above scenario installed capacity will rise between 5.3% and 7.3% p.a. from a 1988 level of 115.5 GW to between 185 to 270 GW. This is an increase, at the higher level, of approximately 12GW per year. Coal will remain the main fuel with a concentration on 1200 - 2400 MW stations on mine-mouth sites and built in conjunction with open coal mines. Some 80-90,000 MW of hydro will also be installed by 2000 representing 32% of installed capacity and 21% of power generated.

The shortage of coal and hydro resources in the coastal region will necessitate the use of nuclear power. 10,000mw is now under construction or planned by the year 2000.

By the year 2000, of the 1200 TWh required, some 20% is expected to come from hydro and 0.25% from nuclear. The thermal efficiency of power plants has improved by about 4% since 1980 but still remains low.

C. South Asia

The total power generating capacity in the public supply utilities of the countries in the South Asia region grew from about 23,630 MW in 1975 to 66,560 MW in 1987, a rate of a little over 9% per annum. The major share of this generating capacity is installed in India (54,195 MW, representing over 81% of the region's capacity in 1987) and of this 33% was hydro and 3% nuclear.

Likewise, annual gross generation in the public utilities of the region increased from about 91,654 GWh in 1975 to 239,649 GWh in 1987, a

rate of growth of 8.3% per annum. Again, power utilities in India accounted for a dominant share (about 84.2%) of the total in 1987.

The rapid increase in gross generation has also resulted in a fast growth of electricity sales by public utilities. Sales increased from about 68,840 GWh to 173,944 GWh during the 1975 to 1987 period, a rate of growth of over 8% per annum. Within this total, Bangladesh had the highest growth rate among the larger countries at 13% per annum; followed by Pakistan at over 10%, India at around 8% and Sri Lanka with 7%.

Despite this rapid growth during the 12 years, sales from electric power utilities have not been able to meet demand. As a result, the power supply reliability of most utilities continues to be poor, and many consumers (particularly industrial establishments) have invested in small generators (usually diesels) for captive use. It is difficult to find reliable data on the installed capacity utilization of standby/captive generators in the non-utility sector in any of the countries, because this generating capacity is owned and operated by a large number of consumers scattered widely throughout the country. In India, data on larger non-utility captive/standby plants show a capacity of 5419 MW (11% of utility capacity), generating 7.5% of the total utility power. In practice, smaller, often diesel, units under 100 KW are omitted from these figures, although there is substantial small scale capacity in the industrial commercial and household sector.

As all the countries of the region are net oil importers, several of them are in the process of developing non-oil-based generating capacity (be it hydropower, nuclear, gas-based or coal-based). Dual-fuel systems may be developed in certain countries, while oil-fired capacity is likely to be used exclusively for emergency operation in others. The slump in the international oil market, which has been there for several years now, does not seem to have deterred the South-Asian countries from diversification of their power generation systems away from oil. This is a reflection of the recognition by the respective Governments of the inevitability of the return to higher oil prices, and their desire to shield their economies to the greatest extent possible when that eventuality arises.

In Bhutan, the total installed capacity of the Chukha hydropower project is 336 MW, while its firm capacity during winter months may be limited to 100 MW only. As maximum demand (for the entire country) until

1992 is not anticipated to exceed 50 MW, a substantial portion of the Chukha power will be available for export to India. Two further 45 MW hydro projects are due for completion in the 1990's.

The power development plan of BPDP in Bangladesh maximizes the use of relatively inexpensive natural gas resources in the east zone. If gas resources are not discovered and developed in the west zone (or gas is not transmitted from east to west) in the medium term, new oil-fired capacity will be added in the west solely to replace old plants. Most of these oil-fired plants will be operated at low plant load factors to reduce system fuel cost, and energy from the east zone will be transmitted to the west zone through the 230 kV east-west interconnector.

In Nepal, two hydropower projects (Marsyangdi, 69 MW: and Andhi Khola, 5.1 MW) are under construction and are expected to be commissioned by late 1989. Although NEA's least-cost expansion sequence indicates that 50 MW of oil-fired gas turbine capacity will be required during 1994 and 1995, NEA plans to undertake a vigorous load management programme to reduce peak demand to a level where it is no longer necessary to invest in gas turbines.

The system in India has become increasingly reliant on indigenous coal and lignite for generation in thermal plants - by 1987, 63% of all capacity was thermal, and the great bulk of this was in solid fuel-burning units. Gas turbine units have been established in a few locations in recent years largely because they can be commissioned more quickly than steam thermal stations and hydroelectric plants. Moreover, gas has become available for power generation in some locations, while in others, diesel oil is used. To reduce oil-based non-utility generation, there are plans to more than double the installed capacity, from 54,195 MW at the end of 1987 to 110,950 MW at the end of 1995; and further to 243,860 MW by 2004.

While expansion plans include a commitment to gas turbine and combined cycle plants and there are some proposals to expand the use of gas in power generation, it is at present expected that oil and gas will be used only where they offer locational advantages (proximity to refineries or gas fields).

As CEB in Sri Lanka has substantial reserve capacity margin (about 88 percent of the peak demand in FY1987), the utility is emphasizing the development of hydropower projects (which have relatively long gestation periods) for the next five years.

In general, if hydropower is to contribute to meeting incremental demand for electricity during the 1990's and beyond, some countries will have to develop large remote resources, perhaps with the cooperation of neighbouring countries. Successful cooperation has already been achieved in certain cases. For example, the Chukha hydropower project benefits both Bhutan and India. Major projects between India and Nepal, including schemes now being studied such as Karnali (3000-6000 MW) and Pancheswar (2000-3000 MW) would also benefit both countries by reducing Nepal's trade deficit with India and supplying cheaper electricity to India's frontier areas. These projects would also provide the added benefits of increased flood control and irrigation. Furthermore, India and Pakistan have also negotiated the Indus Valley Treaty for cooperation in the management of water resources of the Indus and its tributaries common to both countries.

System losses in nearly all utilities in South Asia are high, for a variety of reasons. Technical losses are high, due largely to underinvestment in the transmission and distribution systems, and the low load density in rural systems. The problem is widely recognised and several utilities have made substantial efforts in recent years to reduce technical losses — often with multilateral or/and bilateral assistance. Non-technical losses are also high, particularly at the low-voltage end, in several utilities. This is due not only to faulty metering equipment and incorrect meter reading, but also because of pilferage, meter tampering and so forth. Laws have been enacted in various countries, and other measures have also been taken, to help control pilferage and meter tampering, but the experience of certain countries (like Pakistan and Sri Lanka) has been better than others. One of the reasons for high non-technical losses is the rather poor power supply reliability (with substantial frequency and voltage fluctuations, as well as brown-outs) in these countries as a consequence of which some consumers are reluctant to pay for whatever electricity they consume.

5.5 Key Issues

A. Northeast and Southeast Asia

Finance and Pricing - Despite an expected decline in the growth rate of electricity demand in most countries of the region, their power expansion programmes still require significant funding to finance load growth. Assuming that past investment trends will continue, the region will need between US\$160 billion to US\$200 billion or US\$8-10 billion per year over the next 20 years. Moreover, the trend towards coal and nuclear, which seems to be the most logical choice for countries lacking in domestic energy resources or striving for oil independence, requires even larger investments than expected because of the associated infrastructure needed to operate these facilities effectively. Harbours and inland transport systems have to be constructed to supplement coal plants, and costly pollution-control equipment has to be installed to minimize the environmental damage from coal plant emissions. Furthermore, the nuclear power plant option, which is in itself very costly, requires the development of an expensive nuclear waste disposal system quite apart from the huge initial investment of the programme.

Thus, two issues of particular importance for the region which require closer examination are how such an enormous investment can be financed by power utilities within the framework of their financial models and national economic planning, and to what extent their current financial systems and tariffs can be adjusted to provide the flexibility required to ensure the healthy development of the resources needed for expansion plans. None of the emerging investment planning patterns are designed to cope with the sort of problems which countries in the region will have to tackle within the type of power expansion programmes that they plan to develop. The continued implementation of strategies relying on external borrowing can only exacerbate the situation by pushing debt services to unmanageable levels and creating problems at the national level such as the deterioration of national accounts, the increase in interest rates, etc. The private sector's participation in the development and operation of the electric power system, which is viewed by many planners in most countries of the region as a possible option in alleviating the problem, is still under discussion, given the wide range of associated problems: from institutional barriers to financial, technical and political risks.

The lack of experience in integrated energy-economy approaches to power investment planning in countries of the region further complicates the problem and makes the search for a balanced national investment policy between energy, transportation, industry and agriculture and rural development difficult.⁶ Furthermore, it is likely that in the emerging global economic situation, external capital flows into the region will not be enough to supplement domestic savings in funding capacity growth and there will not be as many opportunities for trade as in the 1970's and 1980's because of the political and economic changes in Eastern Europe.

The financial problem assumes an even larger dimension, particularly for debt-ridden and capital-scarce countries of the region, if power utilities continue to face difficulties in implementing tariff adjustments which can enable them to attain reasonable rates of return and adequately finance their investments from internal revenues. Although recent policies have significantly improved the financial performance of power utilities in most countries of the region compared with past records, their current positions cannot be considered stable, and large fluctuations on financial returns can be expected in the future since structural weaknesses, such as the relative share of debts, the weight and influence of governmental administrations, etc. still exist in the financial and institutional systems dealing with power resources development.

The prospects of reducing the level of investment, as a result of the improvement in load forecasting methodologies and management policies, of conservation efforts, of using less capital intensive fuel options etc., have not been extensively and thoroughly examined in the region. However, while it is recognized that potential for investment saving exists, the way in which the region, as a whole, plans to capitalize on this depends on its capacity to formulate policies with a clear focus on the development of cost-effective power systems, optimum utilization of national resource endowments and the transmission system and the conservation of electricity.

Technology - Most countries of the region are faced with the problem of low technological performances of their power utilities. In the region, it is common to find power utilities with thermal power plants with availability factors of less than 40 percent (the average plant availability factor for the whole region is about 43.2 percent) and a high

fuel use per kWh of output (20 percent more than efficient plants). The reason for this is that insufficient resources are allocated for maintenance and repair; power plants are poorly managed; fuel used is of poor quality; and, in most cases, spare parts are lacking due to scarcity of foreign currency needed to import them. Although South Korea and Taiwan possess the technological capabilities to master and manufacture some components of power technology, the region, as a whole, still depends on suppliers from developed countries.

The future shift to natural gas, coal and nuclear as the main sources of fuel for electricity production will accentuate the region's technological dependence on Western countries and Japan, particularly for nuclear technology. If coal is used extensively for power production, the transfer of more efficient and environmentally clean technologies of coal combustion needs to be organized between the region and industrialised countries. There is also another component of power technology which merits highlighting because of its significant role in the overall power utilities' technological performance: plant management techniques. This "soft" technology element, which is closely linked to the "hard" technology element (power plant), should be developed locally and strengthened to make the best use of the transferred technology. Furthermore, an urgent task for most governments of the region is also to build R&D capabilities to carry out necessary technological adaptations and innovations to suit local conditions of utilization.

The management of the development of the power technology-mix is also an important issue in the context of utilities' performance. Thus, in countries where combined cycle plants are used, performance is improving. But in the future, the shift towards nuclear plants in Northeast Asia might not lead to a significant increase in system reliability unless measures are taken to ensure high quality construction and operations personnel and procedures.

Improving the technological performance of power utilities is, nowadays, gaining more and more consideration in the region since it is recognized that inefficiencies in the power-sector result in productivity losses and long-term costs to the economy. Thus, uncontrolled load shedding and transmission and distribution outages, as a consequence of

operational inefficiencies, lead to significant damage of industrial equipment and financial losses. Where there is controlled load shedding, the consumer can effectively minimize losses by reorganising the production process, but, its long-term costs will increase because stand-by generation capacity (i.e. installation of diesel generator sets) will be developed. Available estimates for Taiwan indicate that electricity interruption costs to the industry sector in 1988 were typically in the range US\$0.06/kWh to US\$2.16/kWh; compared with an average tariff per kWh sold to industrial Taiwanese customers would be willing to pay up to thirty-six times the average tariff in order to avoid the adverse effects of interruptions.

Environment - The region's power system has been expanded with very little attention being paid to the environmental impacts; however, peoples' attitude to environmental problems associated with electricity production is rapidly changing after the accidents at Three Mile Island and Chernobyl. The environment has now become an important issue; in the past, hydropower development plans have been studied and implemented within a strictly technical and economic framework and perspective; thus, large populations were relocated with very little concern for the effects on their lifestyle and survival; changes in river basin ecologies were disregarded and large forest areas were sacrificed without any assessment of the losses caused by the disappearance of valuable forest species. But nowadays, government policies in the region require environmental assessments to be carried out and discussed before any decision can be made. The case of the Nam Choam hydropower dam in Thailand, which was stopped from being built because of the severe environmental impacts that it would have, typifies the emerging trend in the region.

The problem of emissions of SO₂ and NO_x from electricity generation has started to gain recognition in the region, but since very few studies exist at present, it is extremely difficult to achieve an extensive view on the situation. Recent estimates available indicate that the total sulphur dioxide emissions from electricity production in the four main countries of the ASEAN (Thailand, Malaysia, Indonesia and the Philippines) in 1985 were of the order of 450,000 tons, or about 54 percent of the total emissions, which include the production of SO₂ from end-use processes. In South Korea, where the level of industrialization is comparatively higher, about 22 percent (230,000 tons) of SO₂ emissions were from electricity production

and 78 percent from other processes. Thus, on a per capita basis, emissions of SO₂ from electricity production in South Korea were about 2.33 times higher than those from the four ASEAN countries, and 5.8 times higher if emissions from other processes are included.

The major concern in the region is that the situation is expected to worsen in the next few decades as economic activities expand and electricity production increases. The planned augmentation of coal utilization in electric power generation, if it materializes, will represent the most serious problem for the region in the future, and some countries will probably suffer more than others because of the transboundary nature of environmental pollution. For example, the massive use of coal in Indonesia would certainly create additional air pollution problems for Malaysia and the southern parts of Thailand and Vietnam in the monsoon season, given the predominant wind pattern which generally blows from south to north. To solve the problem of emissions from coal and fossil fuel used in power generation, will certainly require the extensive use of state-of-the-art technologies to control sulphur dioxide emissions and other policy measures to improve the utilization of electricity (conservation) and, thus, reduce the size of the power expansion scheme.

The case of nuclear energy development for electricity production in Northeast Asia raises the issue of waste disposal. The region is not yet equipped with the waste disposal technology which has been developed by a few countries in the world (i.e. France, United States and Japan). Furthermore, an important aspect of the nuclear programme in the region, which should not be neglected, is that it does not produce emissions of SO₂ and other particulates; however, this should not conceal the fact that large resources and safeguards need to be developed to ensure that nuclear plants are properly managed and do not represent a threat to the environment.

Although the present attitude towards the environment in the region differs markedly from the past, it should be highlighted that numerous problems still remain, and these will make the demand for a better environment more difficult and uncertain. The most important problem is probably related to the lack of a strong constituency for action to monitor impacts on the environment, and to initiate environmental assessment

studies of development projects. A related problem is the absence of stringent emission regulations as well as the lack of tools which can assist decision makers to evaluate consequences of pollution and to determine cost-effective measures to alleviate impacts on the environment. Experiences in western countries have shown that some environmental problems can be contained and solved provided the region confronts the problem and adopts the appropriate policy, entailing institutional and technological solutions.

Electrification - Except for Singapore and the countries of Northeast Asia, the level of electrification is relatively low in the region. Available estimates show that less than 20 percent of the population in Indonesia, Laos, Cambodia, and Burma have access to electricity. For the middle-income countries (Philippines, Thailand and Malaysia) with GDP per capita ranging from 1,000 to 2,000 US Dollars (1980), the percentages are comparatively higher - about 50 percent in 1985, 65 percent in 1987 and 82 percent in 1985 for the three countries respectively. In addition to low levels of electrification, levels of per capita consumption are also very low. In the four main ASEAN countries for example, the average per capita consumption was in the order of 270 kWh in 1987 - assuming that total system losses were 15 percent - which represented about 4 percent of the OECD average.

The progress of electrification in many countries in the region is crucial in many respects. In Southeast Asia and Indochina, where traditional fuels are still very extensively used (total uses account for more than 35 percent and 75 percent of the total energy consumed respectively), especially for cooking purposes in the rural household sector, alternative fuels need to be made available in order to reduce the growing pressure on traditional energy sources (i.e. wood and charcoal mainly) and, thus, the serious consequences on the ecology and environment. Rice is the region's staple food and it is traditionally cooked by using either a wood or a charcoal stove; as income levels increase and electricity is made available, rural people start to equip themselves with an electric rice cooker, which is a much more convenient way to cook rice. Thus, electrification, in the more general context of development progress, contributes to alleviating the environmental problems (deforestation) caused by the excessive use of wood and charcoal by households.

Very often, electrification is also considered by government planners in the region as an important factor for productivity growth and poverty alleviation, although available literature indicates that the correlation between electrification and socio-economic development is not a straight-forward equation, with rather complex linkages which are certainly not yet well understood. However, it has been observed that socio-economic benefits have not occurred as rapidly and automatically as expected when the countryside moves from darkness to light. When the socio-economic development process has taken place, this has been the result of a combination of a large number of factors such as road infrastructure development, irrigation facilities, banking services, etc., and electrification has played only one part in the general process. Although the role and importance of electrification within the economic development process remain to be evaluated carefully, especially in the context of growing supply costs and pressure to eradicate cross-subsidies between regions and between sectors, it will be extremely difficult for governments of Southeast Asia (except Singapore) and Indonesia to justify the idea that a segment of the national population will never get access to modern lifestyles which are generally associated with electricity. To a large extent, the credibility and political stability of many governments in the region depend on the progress of electrification.

The continuation of the electrification process has already created serious problems in terms of availability of financial resources to expand power supply systems for sustainable social and economic development. Furthermore, many governments are now also recognising that the high costs involved in rural electrification programmes, will probably never be recovered normally because of the current pattern of electricity uses and low income levels. Thus, without innovative approaches to solve the problem of electricity needs for socio-economic development and without the availability of resources for power expansion, it will be difficult for governments to avoid choosing between investing in new generation projects or pursuing electrification projects. However, it is almost certain that electrification projects will receive comparatively less priority because of their generally poorer financial returns.

B. China

Finance and Pricing - There has been a chronic under-investment in the power sector for many years. Electricity has attracted between 4 and 9% of

gross capital formation in the period 1957-1980. In the 1980's, the figure has risen gradually from 7.6% to the 1985 level of 9%. Nevertheless, there has been a consistent imbalance between investment in the power sector and investment in power using industries. This results from the instability and randomness of policy making.

Over the years, the State Planning Commission has controlled a declining share of the nation's investment. Before 1978, it was 75%, by 1980 it had fallen below 50%, and by 1985, it had fallen to 25.1%. Thus, Central government is no longer able to affect national fixed capital investment directly, but at the same time it has not developed the capability to control events by the indirect means of taxation, prices and the other levels of macro economic control. Furthermore, there is no capital market to facilitate the financing of new infrastructure.

By transferring much of the responsibility for investment to local government and to the level of enterprises, capital is flowing into activities that are small in scale, fast to build and high in profit (such as alcohol, cigarettes, etc). Although profit earning enterprises are hampered by lack of electricity, there are few incentives to invest in new capacity. However, since 1986, local governments and enterprises have begun to play the principal role in electricity plant construction and power production. This has been encouraged by the implementation of a policy which states that "Those who need electricity must invest in it and those who invest can decide its distribution". This new system involves raising capital from multiple channels and expanding power capacity following many models.

At present, the electricity sector obtains capital from the following sources:

1. State-owned capital, but this is changing from central allocations to bank loans.
2. Local electricity construction funded mainly by raising the electricity tariff rate by 0.02 RMB per KWh.
3. Foreign funds, being utilized by Huaneng International Electricity Development Corporation (HIEDC) and several other organisations.

4. Funds from the project of Substituting Oil With Coal, being executed by Huaneng Electricity Generation Corporation (HEGC).
5. The funds generated from selling electricity capacity (most of the capacity is sold at the price 2500 RMB per KW).
6. Electricity construction bonds issued by the provincial power authorities, power grid authorities and local governments.
7. Government provided fund for mini-thermal and mini-hydro power-plants, mainly for rural electrification.

Since China adopted the open policy towards the outside world, foreign funds have been welcomed especially in the electricity sector. Since 1979, the electricity sector has been one of the major sectors to attract preferential loans from foreign governments, international financial organisations, and export credit organisations. In the last 10 years, the ESI has entered into contracts for loans, grants and export credits with the World Bank, the Japan Overseas Economic Cooperation Foundation, the Kuwait Arabian Development Foundation and some United Nations organisations as well as the governments of Canada, France, Norway, Australia, Britain, Finland, etc. The total is 4.4 billion US dollars for 24 projects in thermal and hydro power plants, transmission and distribution, with a total installed capacity of 17 GW.

Loans from World Bank are the main source of foreign fund in the electric power sector. In addition to this, foreign companies have invested directly in some areas, for example, the nuclear power station in Guangdong is a joint-venture of Hong Kong Nuclear Power Investment Incorporation and Guangdong Nuclear Power Investment Incorporation. The Soviet Union and Eastern European countries have supplied equipment for 200 GW and 500 GW thermal power units by means of open accounts, grants, barter trade, and loans.

The current institutional reform of China's economic system plans to implement a planned commodity economy on the basis of a publicly-owned system. After 1989, the dominance of the planned economy has been emphasised more than before. According to this system, prices of major commodities should be set or approved by the government. Therefore, the pricing or any adjustment of electricity rates must be approved by planning authority.

Since 1953, the central government has controlled electricity pricing and adjustments, and has approved a nationwide rate schedule by which charges for energy, capacity and power factor have begun to be implemented for large industrial customers.

Some variations have been allowed over the years to subsidize power use in agricultural and electricity intensive industries (such as aluminium) and to account for the rising share of high cost power from thermal plants in the North East. Average tariffs have been approximately 0.07 RMB per kWh for the whole period 1955-1986 (this is currently about 0.02 EW/kWh). Such a low price stifles supply and encourages waste thereby contributing to the acute shortage of electricity. A reasonable tariff must be charged to allow supply companies a level of profit after all costs (including depreciation) similar to all other national industries.

Technology - An annual increase in generation capacity of 12 GW per year is attractive both to Chinese and foreign equipment suppliers. Since 1986, some 14-15 GW of capacity has been agreed with foreign suppliers and much more is under discussion. Shortage of domestic capital forces China to look to foreign suppliers who can raise finance, but the resulting foreign equipment is charged at levels above world prices. For instance, the cost per kw of the Qingshan is 4 times the capital cost of thermal plant. (In the Soviet Union and Japan, investment costs may only be 25-30% of those in China.)

China is taking a number of steps to develop local capacities to supply capital goods. First, the government urges power suppliers to use local equipment. Harbin, for instance has the capacity to produce four 600MW plants per year. It is important that this capacity is used and that local people learn from this experience. Second, China will reduce protection to inefficient local supplies. Equipment must be imported to meet the serious shortage, but these imports will be increasingly for advanced equipment and will include the importation of managerial skills. Efforts are being made to obtain technical capability through joint ventures, coordinated bidding, importing plant parts for local assembly. The aim is to digest and absorb the knowledge associated with the import of parts.

Third, greater use will be made of competition, not only from abroad but among Chinese suppliers. Foreign suppliers have the advantage of quality while local suppliers can offer lower prices and better service.

Fourth, competition among local producers will be used to diffuse best practices through coordination and building on strengths.

Environment - China's environmental pollution is very severe. The energy sector, including the electricity industry contributes significantly to this pollution. Atmospheric pollution from thermal power plants is particularly serious. Many power plants burn coal with low heat values and high ash content; they use wet or mechanical dust collectors with an average efficiency of about 80% and so fly ash pollution is serious. The sulphur content of the coal burned by power plants varies from 0.2% to 6%. Coal with sulphur content in excess of 2% accounts for about 25% of the total. Sulphur dioxide pollution is very serious for power plants burning such coal. At present, sulphur dioxide pollution abatement is based mainly on the use of high chimneys. For power plants built in recent years, chimneys of 160-240 metres have been used.

China is now beginning to tackle the environmental problem. In particular, the environment protection bureau and other authorities must now approve all plants for power plant construction. These measures were again strengthened in May 1989.

In order to reduce the environment pollution caused by particulates emitted from power plants, many old type wet scrubbers which were extensively used up to the 1970's have been improved. A new type of electrostatic precipitator has been developed and successfully put into operation. A number of power plants were selected to conduct trials on the performance of bag filters on an industrial scale. As for flue gas desulfurisation, pilot plant tests have been conducted on the two 350 MW units of the newly conducted Luo Huang Power Plant in Chongqin. The devices were imported from the Mitsubishi of Japan.

Although the yearly coal consumption of power plants in China with a capacity of over 50 MW has increased 50% from 1985 to 1988 (70 million tons), the total amount of ash released to the atmosphere in the same period increased by only 15% (0.5 million tons).

China plans to develop integrated control of emissions with a range of other policies. These include:

1. Energy Conservation. Energy waste is a major reason for environmental pollution. China's energy structure depends on coal, and special attention is therefore paid to the development of high parameter large-scale units and the development of district heating and cogeneration to reduce household coal consumption.
2. Giving greater emphasis to the construction of mine-mouth power plants in collaboration with the exploitation of large coal mines. Pollution is thereby moved away from urban areas.
3. Popularising the use of electric scrubbers and dry scrubbing technology in order to save water and reduce the secondary pollution.
4. Improving coal dressing to decrease ash content, in order to alleviate the burden of transportation and reduce atmospheric pollution of the power plants in urban and coastal areas.
5. Stopping ash emission to the rivers completely.

Electrification - Strenuous efforts are now being made to increase, from the present level of 60%, the number of rural people with access to electricity. Connection to the grid will be the main approach, but where this is not possible, decentralised systems, using wind and biogas, are being researched. Cost can be reduced by setting lower standards for voltage fluctuations in rural areas, but efforts are being made to upgrade circuits to three conductors (rather than the two wire one to earth system).

Energy resources are abundant in the west of the country, but economic development is concentrated in the eastern coastal repairs. This presents huge transport problems and offers considerable potential for regional policies. In particular, industrial development must be matched to the local energy supply position.

C. South Asia

Finance and Pricing - The total utility capacity in the South Asia region is anticipated to increase from 66,560 MW to 472,310 MW in 2010 (in a low growth scenario) and to 549,404 MW (in a high growth scenario). This calls for massive investment levels over the next twenty year period, and utilities in the region will have to continue to rely heavily on external sources of funds to achieve these growth targets. India's share of installed capacity is expected to remain at four-fifths to 2010.

In India, the financing of power sector projects is integrated into overall public expenditure planning. The dominant investors are the State Electricity Boards (SEBs) and their sources of funds are: State Government loans, loans from financial institutions, open market borrowings, internal resources and Central Government assistance. The open market borrowings of SEBs are governed by Planning Commission and State Government decisions and these are fully guaranteed by the respective State Governments. The shares of these sources in total financing vary widely by State.

The internal resources generated by public enterprises are a part of overall plan resources. However, investment programmes are planned irrespective of the level of internal resources generated by the public enterprise. During the Sixth Plan period (1980/81 to 1984/85) about 16.8 percent of the public sector outlay was financed by the contribution of public enterprises (i.e. self-financed). During the Seventh Plan period (1985/86 to 1989/90), this contribution was expected to be about 19.7 percent (i.e. Rs.354.85 billion at 1984-85 prices).

The SEBs were expected to incur net losses to the tune of Rs.15.69 billions, during the Seventh Plan, after raising an additional Rs.60 billion. The outlay for their investments was about Rs.226.87 billion. The quantum of extra-budgetary resources is limited in the case of SEBs, unlike the central sector projects which are able to mobilize more resources. Thus, the bulk of the investment financing in the power sector (especially the State sector) is through the budget. Such heavy dependence on budgetary resources leaves the SEBs with very little financial autonomy in planning for and mobilizing their investment funds.

Once a project is included in the plan, there is a virtual guarantee of funds to cover costs irrespective of any time overruns or cost overruns that the project may suffer. However, there is a considerable uncertainty regarding the amount of funds that would "actually" be made available to the power projects, especially the ones in the state sector during the different years of the plan (this is in fact a major factor contributing to cost escalations and delays in projects). Whenever there is an overall resource crunch or when the actual resource mobilization does not match the estimated figure, then the allocations made to the power sector, and the allocations made to different projects within the power sector, are considerably modified. In such situations, on-going projects or projects nearing completion normally received priority. Thus, the SEBs have assurance of the investment funds available to them only on an annual basis.

This non-availability of investment funds on a committed basis over a long-range planning term forces SEBs to carry out their investment programmes in an ad-hoc manner based on short-term considerations. Trying to circumvent this problem the SEBs try to include many new schemes in each plan period, by deliberately under-estimating their investment costs. The idea is that once a project is included in the plan, then it would be seen through, whatever the cost escalations or delays in commissioning.

As a short-term measure to manage this problem, the Power Finance Corporation (PFC) which was set up in July 1986, raises resources outside the plan budget and finances generation, transmission and distribution projects, renovation and modernization projects, system improvement and energy conservation projects in the power sector. The PFC stipulates certain conditions in regard to the financial position of the SEBs in order that they may be able to meet their debt-service obligations.

There is, however, an urgent need to undertake some long-term measures in order to have the investment programmes in the power sector more efficiently executed and in an economic manner. There is no doubt that the SEBs will have to improve their financial performance and raise their self-financing ratios. All the investment finances (budgetary and extra budgetary) made available to the power projects could be channelled through a single body. This body could analyse the corporate plans and detailed

project reports of individual projects and make provisions for the investment programmes on a committed basis over a long-term (maybe 5 years, to coincide with Plans). This body could at the same time stipulate certain conditions for the financial viability and internal resource generation of the power utilities as a prerequisite for receiving investment funds.

Tariffs in most countries of the South Asia region are in principle related to either rates of return or the need to finance a proportion of current investment from internal sources. But in practice there is frequently a compromise between these financial objectives and the actual tariff structure determined by socio-political criteria, especially the perceived ability of different consumer groups to pay. For instance, in India the Electricity (Supply) Act of 1948 stipulated that tariffs assessed by the SEBs should meet all operating costs and capital charges, and earn a rate of return as specified by the state governments. Despite this last condition, none of the state governments impose a mandatory rate of return on the SEBs. Rather, the emphasis is on providing power for industrial and agricultural development at affordable rates. The agricultural sector and low income domestic consumers are heavily subsidised in most of the utilities. To encourage industrial development, many states also offer low rates to large industries.

As a result of these policies in India, many utilities incur heavy financial losses and are unable to generate sufficient resources to finance the additional investments required by the increased growth rates in the demand for energy. Power shortages, which affect the productivity of the industrial and commercial sectors are, therefore, common. To improve the financial operations of the SEBs, an amendment to the Electricity (Supply) Act was introduced in April 1985 requiring all SEBs to earn a minimum 3 percent return on their net fixed assets, after meeting all expenses, with interest during construction capitalised. However, because most SEBs still do not reach that level, efficient operations and investment continue to be constrained by limited resource mobility.

At present, at least in theory, the Indian state governments have agreed to subsidise the losses incurred in agricultural sales. However, actual practice is very different. Many state governments do not give a

subsidy at all; in a few cases, even where officially provided, the actual cash flow does not take place. In some states, there are disputes as to the correctness of the claims made by SEBs. In some of the SEBs, the subsidy is not enough to enable the Board to have a surplus. The subsidy due varies from under 10% of SEB income in some state to over 25% in others.

Tariff structures and levels in nearly all countries need to be rationalised to achieve more efficient performance in the power sector. For example, one impact of the present tariff structures in India is to move diesel consumption from isolated rural areas (where diesel pumps are being replaced by electrical pump sets) to industrial consumers who are obliged to install captive generators because of power shortages. Also, rather than adjusting tariffs to meet a utility's financial viability or national economic efficiency, social goals and equity considerations have guided most tariff policies and revisions. Though these social goals are important, a more equitable trade-off between the objectives could be achieved.

Technology - Bharat Heavy Electricals Limited (BHEL) in India, a wholly Indian power equipment manufacturer and supplier, has the capability to design, engineer, fabricate and install generating units of up to 500 MW capacity each. The company can also meet some export requirements. However, power system development in most countries of the South is financed by bilateral or multilateral sources which often also limit the choice of equipment suppliers. India has also developed a large pool of technically-trained manpower in the electricity sector. This manpower can help in the planning, installation and operation of power plants in the South, as well as train local manpower to carry out these functions. Consequently, India has the capability to undertake power projects on a turnkey basis.

Nevertheless, factors such as availability of trained manpower for construction, operation and management of electricity systems may prove regionally to be a limiting constraint to meeting future demand. In this context, utilities of South-Asian nations need to give particular attention to transmission and distribution loss reduction and load management programmes. Such schemes have been demonstrated to be economically

attractive and commercially viable in several countries in other parts of the world. At present, not much seems to have been done in this regard in South Asia, and it may very well be that the utilities of the region need to be pushed towards adopting such measures. Recent initiatives adopted by multilateral and bilateral lending agencies towards financing such projects is a welcome step.

Environment - It is difficult to believe that the system capacity expansion targets outlined above can be met. It is not only that the investment requirements for setting up generation capacity and concomitant transmission facilities will need to be high, but also that environmental considerations will play a larger role in the future particularly for large hydro projects with dams, and for areas where a high concentration of thermal power stations is envisaged.

In India, environmental impacts have not yet had a major direct impact on the development of the sector. However, they have slowed down the process of planning and construction, and also added to costs. It is expected that environmental consequences may become more acute in the foreseeable future owing to ash disposal problems in the case of thermal power stations, and to rehabilitation of displaced persons in hydro projects. Major technological changes in thermal power generation may also come about so as to achieve higher efficiencies and thus reduce total emissions.

Environmental issues have come to the forefront of the electricity planning process in India during the last decade. All planned power projects are required to submit an Environmental Impact Assessment (EIA) study and an Environmental Management Plan (EMP) to the Ministry of Environment. These have to be approved before investment for the project is sanctioned. The Ministry of Environment has specified certain broad criteria which are to be satisfied. These primarily relate to the environmental impact on vegetation (including forests), hydrology and air and water quality, and to the displacement of human population. Thermal power stations are also required to meet air and water quality standards set up by the Central Pollution Control Board. Standards relate to the emission levels of particulates. In addition, ambient levels of particulates and SO₂ for three types of land use (protected, residential and mixed) have also to be satisfied.

At present, the major environmental impacts of thermal power stations in India are particulates, oxides of sulphur and ash. Particulates have been effectively controlled, but the debate on SO₂ control is continuing: at present, there is only one power station in India which has a flue gas desulphurization unit. Indian coals have low sulphur content (0.2 to 0.4%), but spatial concentration of installed capacity could lead to high SO₂ concentrations which may lead to a change in government policy in as much as SO₂ emission standards may be specified. Indian coals have high ash content (35-50%), and consequently, ash disposal is a major problem. No effective solution to this problem has yet been established, and in the long run, this may be the major constraint in the growth of thermal power. It may also be noted here that the government has seriously started considering policy responses to address the global warming issue so as to reduce CO₂ emissions. This may lead to the adoption of efficient new (and more expensive) coal combustion technologies.

As far as Indian hydropower is concerned, the major impacts are displacement and reservoir siltation. In the past year, public outcry against "large dams" has slowed the construction of dams. The debate focuses on the rehabilitation of displaced people and the nature and magnitude of compensation. This has led to the questioning of the cost-benefit structure of hydro projects, and a "large number of small dams" are suggested as an alternative. The rapid siltation of reservoirs has also emerged as a major issue in hydroelectric projects. Deforestation of catchment areas has led to siltation rates which are several times as high as the designed rate, and consequently result in reduced storage.

Electrification - Interconnections are a potentially important issue for this region. The power systems in the East and West Zones of Bangladesh were interconnected in December 1982 by a 230 kV double-circuit transmission line. Power exchanges between the two zones have led in general to a reduction in total system generating costs by substituting oil-based generation in the West by natural gas based generation in the East, as well as to improvement in the overall power supply reliability. As mentioned above, interconnections exist between Bhutan and India (Bhutan has excess hydro capacity). In Nepal, a 132-kV line of NEA is interconnected with Ramnagar in India. At the distribution level, there are 14 other interconnection points along the India-Nepal border. Power

exchanges are arranged on an ad-hoc basis, depending on availability; and power supplies to isolated systems, from the Indian grid, remain unreliable.

For a variety of reasons (the important ones being improving the quality of life in rural areas, curbing rural to urban migration, and stabilising agricultural output), the Governments of South Asian countries have accorded a high priority to rural electrification. Specific financing institutions and/or distribution agencies have been set up in several South Asian countries, which once again shows the emphasis laid by the respective Governments on rural electrification. Several countries have set a target for achieving complete rural electrification by the turn of the century or before. However, relatively few rural households have access to electricity at present. Substantial investment is required before a 100% access to electricity can be assured, and in general, the schemes need to be appraised very carefully and priorities for rural electrification clearly established.

6. LATIN AMERICA

6.1 General Description

Latin America is a relatively rich developing region (GDP of \$1809 per capita); its population is only 8.2% of the developing countries' total but its share of GDP is much higher (31.5%). This wealth was acquired mainly during the 1950's and 1960's when many countries of the region adopted import substituting industrialisation policies to encourage the development of an industrial sector. During that period, economic growth was high enough to provide substantial improvement in living standards for a rapidly growing population, especially in urban areas.

At the end of the 1960's however, the shortcomings of import substitution policies began to emerge. The need was recognised for profound changes in domestic policies in order to sustain economic growth in the long run. The challenge facing the industrialising economies of Latin-America was in many ways made more difficult by the oil crisis. Indeed, in the 1970's the availability of large financial resources at low (and even, for a while, negative!) interest rates led countries of the region to borrow heavily in private markets to finance import substituting industrialisation programmes⁽¹⁾, which were ambitious but not always wise.

The rationale for these policies was the same in both oil-exporting and oil-importing countries: to foster industrialisation and create a sustainable surplus in the long term trade balance. For oil-exporting countries like Mexico, the prospect of unexpectedly large oil revenues apparently offered an exceptional opportunity to encourage industrialisation and prepare the country for the post-oil era. For oil-importing countries like Brazil, industrialisation was meant to reduce imports, and hopefully increase exports, so generating a surplus to pay for oil.

The outcome was extremely disappointing if not disastrous; indeed, the 1980's are recognised as the "lost decade" for the region. Latin-American

economies plunged into a profound crisis and so lost their dynamism that their per capita GDP levels are today at the same level as those at the end of the seventies, if not lower. Although population growth is slowing down substantially, no prospects of economic recovery have yet emerged; it is, therefore, quite likely that per capita GDP will deteriorate even further in the near future.

This result is mainly the outcome of a radical reversal in the 1980's of previously advantageous conditions offered by international markets, although it was exacerbated by the inability of Latin-American governments to enforce domestic policies suitable to the emerging international conditions. Facing a sudden and dramatic collapse of capital inflow, Latin-American countries were forced very rapidly to convert large deficits in their trade balances into large surpluses in order to maintain financial and technological links with industrial countries. This has been only possible through a severe reduction in domestic consumption, and thus a deterioration in living standards which was resisted by their populations. Unable to cope with contradictory domestic and international pressures, most Latin-American governments adopted inflationary policies which eventually led to the stagnation of their economies.

The traditional optimism about the future of Latin-America has been replaced by scepticism; unless the service of the external debt is reduced to reasonable levels, Latin-American countries have little if any chance to re-establish the technological flow that is essential for their economic development. The Brady initiative attempted to address this issue but the results achieved so far are not encouraging. The future is full of uncertainties that make the assessment of the development of the ESI in the region a difficult task.

6.2 Institutional Structure

The infrastructure for the supply of electricity is quite developed in most Latin-American countries. Large grids cover the bulk of their territory and population; interconnections with neighbouring countries do exist and enable, in some cases, large trade in electricity; urban areas are almost completely electrified, although not always supplied regularly. The main remaining weakness is the low level of electrification in rural areas.

Nationalised utilities emerged, often after the war, to create national grids and foster the development of electricity supply, a development that had been restricted under private ownership. Distribution and generation are generally undertaken by different utilities, and in some countries (Argentina and Brazil for instance) several utilities exist for both generation and distribution. These utilities are generally under the control of a Ministry of Energy, in most cases created after the oil crisis to coordinate policies for different energy sources. The Energy Ministry regulates the industry and formally decides on pricing and investment issues in conjunction with the Ministry of Finance. In some countries, a National Energy Commission coordinates energy related issues between different Ministries.

Until the 1970's, utilities had no difficulty in getting government authorities to endorse their price and investment policies. The ESI was able to develop smoothly, offering an increasingly reliable service to a growing share of the population and a larger area of the territory. However this situation has changed drastically. Facing strong inflationary pressures and severe shortages of financial resources, the Exchequer has removed ESI pricing and investment policies from both utilities and energy authorities. Decisions relating to these issues were thenceforth (and still are) made largely on macroeconomic grounds, with very little concern for the profound implications that such decisions have for the financial and economic situation of utilities. This approach is clearly a main source of ill-conceived decisions that are leading to a rapid deterioration in the ESI's performance in the region.

6.3 Trends in Electricity Demand

Latin-America per capita consumption of modern energy sources is 0.98 Toe and its share of modern energy consumption of developing countries is 24.6%, reflecting its large GDP share (31.0%). As always, oil products dominate energy consumption, but natural gas, coal and particularly electricity are increasingly replacing oil products in the satisfaction of energy needs in this region of the world. In the last 30 years, traditional fuels have been largely replaced by modern fuels in urban areas but remain an important energy source in rural areas⁽²⁾.

During the 1970's energy consumption increasing relatively fast in Latin-America (4.2% a year) as a result of industrialisation, urbanisation and population growth. Energy consumption per capita was increasing in every sub-region although energy consumption per unit of GDP was stable or even decreasing (Brazil), except in the Andean Pact. Differences among sub-regions in per capita energy consumption were diminishing, except in the Central American case, while levels of energy consumption per unit of GDP were relatively similar. Nevertheless, different rates of growth of the economy, of population and of urbanisation were inducing substantial changes in the shares of energy consumption among sub-regions. Brazil and the Andean Pact increased their shares, while the shares of the South Cone and Mexico fell.

In the 1980's, the economic crisis slowed down the rate of growth of energy consumption and radically changed the trends. Energy consumption per capita stopped increasing and actually fell in some sub-regions; energy consumption per unit of GDP however increased or stabilised (Brazil and Central America). Substantial changes in the share of energy consumption between regions occurred as well; the most striking change was the reversal of Mexico's previously falling share. In fact, Mexico (which became a large oil exporter) was the only sub-region to increase its share in the 1980's; Brazil, the South Cone and Central America, all oil importing areas, reduced their share in the same period.

Continuous growth in both urbanisation and population has been a key factor in these processes; a fast growing urban population led to increasing energy consumption in transportation and households; while in industry, in spite of the crisis, energy consumption was pushed upward by a substantial growth of energy intensive industries such as petrochemicals (Mexico, Brazil and Venezuela), steel and aluminium (Brazil and Venezuela) and paper (Brazil) combined with a deterioration in energy efficiency (because of the under-utilisation of plants and the lack of replacement of old, inefficient units).

As far as electricity is concerned, it is possible to identify a strong trend to electrification in the 1970's both in urban and rural areas. Indeed, in the 1970's electricity was made largely available to urban populations and there was also a substantial increase in the share of

rural populations supplied with electricity; moreover, there were substantial increases in the shares of electricity in the energy consumption of industrial, household and service sectors. The combination of these two trends meant that there was a rapid increase in electricity consumption (9.3% a year). This raised electricity consumption per capita quite quickly, although electricity consumption per unit of GDP increased much less rapidly.

Although trends were similar in all sub-regions, in Brazil the increase in electricity consumption was particularly marked (12.4% a year) as a result of the rapid diffusion of electric appliances in households and services plus an increase in electricity intensive technologies in industry. These movements produced a rapid penetration of electricity use as compared to other Latin-American sub-regions and resulted in an increase of 11.4% in Brazil's share of electricity consumption in Latin-America.

In the 1980's, there was a slowdown in these trends. In fact, electrification in urban areas had already achieved quite high levels and only a few small towns remained without electricity. The main problem in urban areas was to extend electricity supply to a fast growing population living in the slums of metropolitan areas like Mexico City. In rural areas, electrification did not cease but became increasingly difficult as the areas close to main transmission lines and roads had already been electrified. Nevertheless, a growing share of the population was supplied with electricity and figures in some countries approached saturation levels. The trend to a growing share of electricity in energy consumption remained, but was weaker. Electricity consumption per head increased slowly, while electricity consumption per unit of GDP accelerated. The trend for Brazil to account for a growing share in the electricity consumption of Latin-America remained, but was substantially slowed down.

Government scenarios for energy and electricity consumption are still quite optimistic. GDP elasticities for both energy and electricity consumption are quite high (over 1.2 for electricity in Mexico for instance); this assumes that trends towards a rapidly increasing energy use will remain despite a general agreement that real prices for consumers will necessarily rise quite substantially in the near future. Moreover, official estimates of GDP growth are considered unrealistic in present

conditions of international financial markets, and in the absence of radical changes in domestic policies which are not, for the moment, likely to occur in most countries of the region. In some countries like Brazil, forecasts made a few years ago (1987) are under review; leaked estimates indicate that figures for the end of this century should be at least 20% lower than previously forecast but there are analysts who believe that the real figure will probably be even lower.

These poorly based forecasts are to a large extent the result of a defective assessment of the real macroeconomic situation of Latin-American countries and their prospects for future economic growth; nevertheless, the inability of utilities to relate macroeconomic trends to electricity supply and demand trends must also not be discounted. Indeed, most utilities of the region still use roughly adjusted historical trends of electricity consumption to forecast future demand. Despite some methodological improvements and disaggregation of consumption among a larger number of consumer groups, methods used by utilities lack a basic understanding of the driving forces behind supply and demand. A substantial effort to improve forecasting methods, especially as far as the role of prices and macroeconomic issues are concerned, is badly needed.

6.4 Trends in Electricity Supply

Latin-America is relatively well endowed with energy resources. Many countries of the region have enough oil resources to supply their domestic demand in the foreseeable future; some are likely to remain oil exporters for a long time. Natural gas resources are not fully assessed but even proven reserves are poorly exploited; this energy source is expected to have a much larger role in the future regional energy balance. Large hydropower resources are still underexploited in South and Central America; hydro resources can supply most of the forecast regional electricity demand to the year 2000. Coal resources are relatively poor, but coal use is very limited for strictly energy purposes and there has never been a systematic search for coal resources in most countries of the region.

Hydrocarbon reserves are mainly concentrated in Venezuela and Mexico but exploration in many other countries is proving to be rewarding. Coal reserves are concentrated in Colombia although there are reasonable

resources of generally low quality coal in several countries. Hydro resources are concentrated in Amazonian countries but large hydro potential exists in the South Cone.

Production of modern energy sources has increased substantially in all countries of Latin-America, except Venezuela, since the oil crisis. Oil importing countries like Brazil made an enormous effort to boost domestic energy supply to reduce their oil bill; others like Mexico rapidly developed their oil supply to increase oil revenues. Venezuela, a large oil exporter before the oil crisis, reduced oil exports as soon as oil prices were sufficiently high to provide a trade surplus with a lower oil output. The result of these contrasting trends in the 1970's was a relatively low annual growth rate of modern energy source production (3.0%) as compared to consumption (6.9%), sharply reducing the regional energy surplus from 132.4 Toe in 1971 to 80.4 million Toe in 1980. In the 1980's, the annual growth rate in energy production slightly increased (3.3%) but growth in consumption was dramatically reduced to a rate of 2.6%; the regional energy surplus, therefore, increased again to 118.6 million toe in 1987.

Excepting Mexico, the main primary energy source used for electricity generation in Latin-America is hydro. This situation results from a strategy, pursued since the 1960's and reinforced after the oil crisis, which gave priority to the development of large hydropower plants to supply the bulk of electricity demand. This strategy has permitted a substantial reduction in oil consumption for electricity generation in Latin-America. Nevertheless, in the 1970's the larger countries of the region started changing their perceptions in so far as hydro resources were likely to be fully exploited by the end of this century. Nuclear power then emerged as the primary energy source that would take over the role of hydro to supply an increasing electricity demand. Countries like Argentina, Brazil and Mexico gave strong support to the development of nuclear power.

In the end, hydro kept increasing its share of generating capacity and although some nuclear capacity came on stream, it did not achieve momentum as a result of extremely poor economic performance. More recently, perceptions in the region are changing again, and turning towards long term strategies for a full exploitation of hydropower which, when necessary,

will be complemented by fossil fuel thermal power generation using mainly coal. Critics suggest that large availabilities of natural gas should lead to review of such a strategy in order to give a significant role to natural gas in electricity generation. The environmental impacts of large hydro schemes, much more efficient gas turbines, and capital scarcity are the main arguments used to support this view.

6.5 Key Issues

A. Electrification

In the 1960's and 1970's, large investments were made in Latin-America to develop the infrastructure to supply electricity. The outcome was an increasing share of the population with access to electricity, first in urban and later in rural areas, and a substantial improvement in productivity. Nowadays, urban households are almost universally supplied with electricity and over 50% of rural areas are supplied as well. More recently, however, investments have been reduced, especially in the distribution of electricity, leading to a deterioration in infrastructure and in the quality of service provided. In some countries like Mexico, the share of the urban population supplied with electricity fell; in others like Argentina and Brazil, although there was no decrease in the share of the population supplied with electricity, the quality of service declined substantially.

Surprisingly, although rural electrification slowed down, it did not stop. Apparently this was the result of a review of technical standards that also offered room for technological innovation. In combination, they reduced substantially the cost of rural electrification, making possible a better use of scarce financial resources to provide electricity to a larger area and a growing number of consumers. Despite these improvements, coordination between the different agencies that deal with rural development issues and funds remains a major problem; in fact, electricity supply is still oriented to household consumption, limiting the developmental effects of electricity supply. Fuller coordination among utilities and rural development agencies should change the current approach; indeed, electricity supply have to be perceived as an opportunity to introduce modern technologies, such as irrigation, in rural areas in order to improve productivity.

The share of electricity in energy consumption is increasing rapidly in every sector in Latin-America except transport. In industry, this is the result of a growing share of energy intensive industries in total industrial output; in households, the diffusion of electric appliances is raising electricity consumption, while in agriculture rural electrification is the driving force. If, as desirable, a larger role is given to railways in transportation, electricity consumption should increase its share in this sector as well. These trends have led electricity consumption to increase relatively quickly in Latin America (7.8% a year between 1980 and 1986), despite the economic crisis. As far as the future is concerned, there are large uncertainties; the rhythm of growth is likely to slow down if the economic crisis remains, but an upsurge in demand could emerge if sustainable economic growth is regained.

These uncertainties are a major challenge for utilities; they have to improve transmission/distribution infrastructure and increase generation capacity in such a way that they will obtain the necessary flexibility to eventually respond to upsurges in consumption. In this context, interconnections of both domestic and international grids are an obvious priority; they provide more flexibility and reduce reserve capacity as well. In fact, interconnection is not a new policy in Latin-American countries which have national grids connecting the relevant power plants; moreover, many interconnections among countries do exist already. To the year 2000, domestic interconnection will be completed in large countries while joint exploitation of hydro-resources on borders will boost international interconnections. Nevertheless, other opportunities, not yet fully evaluated, still exist, for instance the Colombia to Mexico link, which would benefit all the countries of Central America as well. It is worth remarking that the Latin-American experience indicates that the joint exploitation of rivers on international borders offers the best opportunity for the interconnection of national grids.

B. Technology

Productivity and flexibility can be increased both from the demand and supply sides, but demand side policies have been scarcely used in the region. Indeed, electricity conservation is largely a rhetorical issue. Brazil has been the only country in the region to introduce an effective

energy conservation policy after the oil crisis; very large incentives were offered for substitution to electricity (hydro generated) from oil. More recently, limited incentives for electricity conservation were introduced but results are so far quite poor. Cogeneration could be another source of flexibility and productivity but utilities are strongly resistant to non-utility generators. For instance, alcohol and sugar producers could provide 2.7 Gw to the Brazilian grid in the dry season, improving management of hydropower reservoirs. However, sugar and alcohol producers still burn surplus bagasse since there is no agreement with utilities as far as both price and reliability of supply are concerned. Management of demand through tariffs is another policy that is just emerging and results so far are very encouraging. Indeed, load factor has been improved substantially in Brazil using time-of-day, interruptible and seasonal tariffs.

The financial crisis has meant that Latin-American utilities' technological performance has deteriorated. Projects had to be postponed and this has had profound implications, especially for those countries like Argentina that were substituting hydro for oil in electricity generation. In Argentina there have been delays in hydropower projects and in completing gas pipelines; in the consequent absence of new hydro plants and the inoperability of gas-fired plants, old, inefficient and badly maintained thermal plants have had to be used in semi-base load mode. This had had disastrous results. Moreover, distribution received low priority and illegal connections resulted, especially among the poor in urban areas. Unsurprisingly, rehabilitation and maintenance of thermal power plants, and distribution losses, are both issues that are emerging in Latin-America and that need to be more carefully assessed by management.

Despite this recent deterioration in technological performance⁽³⁾, some countries of the region have acquired substantial electricity-related technological capabilities, using the purchasing power of public utilities to develop the domestic supply of capital goods. Hydropower technological capabilities have been substantially mastered in Brazil, which has installed the capacity to build 9.0 Gw of hydro-turbines and 7.6 Gw of generators each year. Mexico has acquired technical capabilities in large thermal plants following the introduction of a standardised design. It is able to supply at least 50% of the capital goods for thermal power plants.

Argentina has advanced significantly in nuclear related technologies and can supply at least 45% of electromechanical components.

Criticism of policies that protect domestic supply of capital goods is growing, as a result of a review of the import substituting industrialisation strategy. In Mexico, costs for the domestic supply of capital goods are at least 15% above international prices; in Brazil, there are indications that collusion among domestic suppliers is increasing costs beyond any reasonable expectations. Officials from utilities believe that some level of deregulation in the supply of capital goods would enhance competition and could be a substantial source of reduction in investment costs, and hence of improvements in productivity. It is worth remembering, however, that collusion exists among international suppliers as well, as Brazilian utilities could discover after a recent bid for the construction of combined cycle gas fuelled power plants.

Nevertheless, technological change remains a major challenge for the region. First, technological capabilities in smaller countries are still limited; regional technological cooperation needs to be reinforced to improve users' technological capabilities. Second, technology policy has emphasised radical innovation and given too little role to incremental innovation in the technological change process; unsurprisingly, many components are imported to supply domestic producers of electricity capital goods in Argentina, Brazil and Mexico, and their costs are high in relation to international prices. Third, coal and natural gas are likely to play a substantial role in the electricity supply of the region in the near future; expertise in these technologies is, however, relatively poor in the region and needs to be enhanced.

C. Finance and Pricing

The financial situation of Latin-American utilities is undoubtedly very difficult. They contracted large external debts with commercial banks in the 1970's, in some cases, as in Argentina, with no material project as collateral. In fact, utilities were used to raise foreign currency to support government macroeconomic stabilisation policies in a period of large economic fluctuations. Eventually, utilities became responsible for a large share of Latin-American external debt. For instance, the share of

Brazilian utilities in the country's external debt (\$102 billion) was 23.3% in 1987; this share is lower in Mexico but only because the Treasury absorbed a large amount of CFE's external debt. This situation represents an enormous challenge for Latin-American utilities. They still need substantial imports of capital goods but their output is not tradeable; their ability, therefore, to raise foreign currency for imports depends very much on the ability of governments to re-establish an inflow of foreign capital.

After the oil crisis, electricity prices were progressively reduced in real terms in Latin-American countries, especially for households, even though utilities' costs were increasing. The rationale for such a policy was that reduction of public tariffs should help stabilise inflation, which was accelerating and producing political instability. In countries like Brazil, where electricity was mainly generated from hydropower, substitution away from oil was an additional argument for keeping electricity prices low. This policy boosted electricity consumption but squeezed utilities' revenues and generated enormous price distortions. In Mexico for instance, electricity prices are lower for low voltage consumers whose supply costs are higher; a similar situation remains in Brazil between middle and low voltage consumers. Distortions also exist between electricity and fossil fuel prices and continue to encourage electricity consumption despite the collapse of oil prices since 1986. However the most serious problem is that average electricity prices did not cover average costs for several years and some utilities claim that this is still so, despite recent increases in prices.

Having to service an increasing debt, at relatively high interest rates, and with reduced net revenues if not losses, utilities eventually became insolvent. Demands emerged from utilities for both government financial support, to reduce the short term debt and financial costs, and very substantial increases in real tariffs to increase profitability and solve long term financial problems. These demands received strong support from suppliers and lending sources, especially as far as the pricing issue is concerned. Governments offered some financial support whenever the fiscal situation made it possible but Government financial situations are also enormously difficult; besides, financial support from governments cannot solve the long-term problem if tariffs are not high enough to pay

costs. These trends offered no real scope for any improvement in the financial situation of Latin-American utilities.

Recently, these trends have been reversed. Investment slowed down and real prices rose somewhat; moreover, marginal cost approaches were used to split average costs among consumers and reflect real costs more accurately. Nevertheless, real prices are still far below both long run development costs and the prices demanded by utilities for a sustainable increase in electricity supply. In Brazil for instance, real average price will almost have to double satisfy utilities' plans to restore a 5.4% annual growth rate of electricity supply. Even so, 55% of planned investments have to be financed either by government or financial markets. The disastrous situation of Latin-American Treasuries means that governments cannot be relied on to sustain investment in the ESI; financial markets, either domestic, international or both must necessarily be a substantial source of financing in the future.

Latin-American domestic financial markets are not in most cases mature as yet; they are likely to face enormous difficulties in raising large amounts of capital to finance long maturation projects such as those of the ESI. External financial sources, either multilateral or private, have become extremely reluctant to provide new loans for the Latin-American ESI. They argue that the economic situation of utilities and the macroeconomic environment have both to be improved first. However, there is no scope for their improvement if no substantial investments are made to develop electricity supply. Facing such stalemate, utilities and policy-makers alike are looking for new ways of financing the development of the ESI that will enlarge the role of private investors in the industry.

The radical British idea of selling the ESI and rolling back government to the role of (light) regulator has not found much political support in the region. The experience so far is pointing to a mix of both private and public capital to operate the ESI jointly, although it is unclear what their individual roles will be. In Mexico, bids for the financing and construction of turn-key power plants were made last year and a few other bids are envisaged this year; however, the government intends to strongly regulate and control the industry. In Argentina, although there are successive declarations from the new government that a larger

role for the private sector in ESI is envisaged, no substantial change in the actual situation has yet occurred. In Brazil, the new government that very recently took power has made declarations that it intends to increase the role of the private sector but has offered no clear statement as yet. In any case, dramatic changes must be introduced in the regulatory and institutional regimes if the role of private investors is to increase substantially in the Latin-American ESI.

The ambiguity of governments on this issue seems to result from the substantial difficulty in building up a regulatory framework to allow the industry to operate with private investors. Indeed, social costs and benefits are hard to assess in Latin-American societies since there are complex equity issues raised by very large economic disparities between both social groups and regions. Moreover, acute macroeconomic problems, especially in the balance of payments, and emerging environmental concern require strong government control of investment decisions. It is worth remarking that experience in the regulation of the ESI is certainly very limited in developing countries and in some ways in industrial countries as well. It is not clear how a regulatory regime can be structured that will both work, and efficiently manage these issues.

For instance, it is unclear how to deal with the critical question of pricing. To boost the role of private investors in the industry, prices have to be substantially increased but should public utilities be allowed to increase their prices as well? To complicate the issue, public utilities claim that if prices are substantially increased, they can, possibly, find financial support for their investment and, therefore, privatisation would from this point of view become unnecessary. Some argue that a double pricing system with one level for public utilities and another for private investors, should be introduced but this obviously means that the regulator would need strong powers as far as pricing policy is concerned.

Moreover, in large countries such Argentina or Brazil there are large cost differentials among utilities supplying different areas of the country. A system of compensation that equalizes prices nationally has been introduced in Brazil and is shortly going to be introduced in Argentina as well. However, utilities which have lower costs are

increasingly opposing such as policy because they claim it rewards inefficiency and penalises efficiency. From this point of view, decentralisation and deregulation would foster competition and reduce costs. Nevertheless, these countries have large regional differences in economic development levels and these cannot be ignored. Similarly, the very large disparities in income between social groups cannot be disregarded, since electricity is a major political issue.

D. Environment

The environmental impact of electricity supply was not perceived as a relevant issue in the region until quite recently. This situation is, however, changing rapidly. In Mexico, natural gas is already replacing some fuel oil in thermal power plants and more is planned to be used in the future; additionally, there is a plan to invest over \$2 billion in anti-pollution equipment to reduce emissions. In Brazil, public hearings have been introduced and a Report on Environmental Impacts (RIMA) has to be approved before the construction of any power station is started. Pressure from environmentalists has already changed Brazilian plans for instance, removing from plans some environmentally damaging hydropower plants in the Amazonia region.

FOOTNOTES

- (1) In the case of the South Cone countries (Argentina, Chile and Uruguay) the foreign debt was mainly contracted to finance naive monetarist policies that led to large reduction of the industrial share of GDP.
- (2) This situation is different in poor countries of Latin-America like Honduras or Bolivia, where traditional fuels still play an important role in energy demand, even in urban areas.
- (3) It is worth remarking that Mexico did improve the performance of its thermal power plants. It carried out a thorough programme to improve both maintenance routines and fuel quality. Mexico is the only Latin-American country that has been investing in thermal power plants, since its hydro resources were already largely exploited.

CHAPTER 7 ISSUES AND OBJECTIVES FOR DEVELOPING COUNTRIES

7.1 Introduction

Developing countries have a number of features in common - absolute poverty, low productivity, poor technological capabilities, large social and regional inequalities, chronic problems of balance of payments - that have major impacts on both the objectives of the ESI and the issues it has to face.

Low productivity of a large part of the population is the fundamental problem. An increase in productivity is an essential element in any sustainable process of economic development and improvement in living standards. It provides room for the elimination of absolute poverty and the achievement of greater social equity; if managed well, it can contribute to offsetting most of the large regional disparities in economic development, and to reducing the mismanagement of the environment that poverty induces. Productivity is not a panacea that will automatically bring developing countries to the situation of industrial countries, but it is an essential ingredient in any strategy for economic development.

Increases in productivity are largely associated with technological change. Indeed, the experience of both developing and industrial countries supports the view that diffusion of efficient technologies throughout society is the most effective way of increasing productivity. Innovation is, however, a complex process that relies on the effective acquisition of technological capabilities. Unfortunately, one of the characteristics of developing countries is their lack of technological capabilities. Efforts to acquire, and improve, domestic technological capabilities are therefore not separable from the general process of technological change.

To acquire investment and innovation, developing countries are, to varying degrees, dependent on flows of technology and capital from industrial countries. Nevertheless, the debt crisis and a substantial deterioration in the terms of trade has dramatically reduced those flows.

Investments were reduced and many opportunities for innovation were lost, thus limiting the scope for improvements in developing countries' productivity. To re-establish capital and technology flows from industrial countries became a priority for developing countries, but so far it has proved very difficult to achieve. Terms and conditions imposed by creditors are tough, and adjustment policies have often led to financial crisis and social unrest. Short term financial problems are overshadowing long term economic, social and environmental issues and generating political instability.

Absolute poverty, low productivity, poor technological capabilities and, more recently, the financial crisis are developing country problems that have had a serious impact on the historical development of the ESI. This chapter identifies these problems as they impinge on ESI objectives, and assesses the issues that the ESI has to face.

7.2 Objectives

The widespread movement to the nationalisation of electricity utilities that emerged after the second world war in the industrialised countries was followed in developing countries as well. Nationalised utilities in developing countries were given the objective of providing cheap, reliable electricity to every region and to all citizens, in rural and urban areas, and as quickly as possible. In some large countries, utilities were given the additional objective of using their purchasing power to foster the domestic acquisition of technological capabilities within a framework of import-substitution policies.

A. Electrification

It was the perception that energy, and especially electricity, supply was a factor that would increase productivity and, eventually, eliminate absolute poverty that led governments to fix such ambitious objectives. More recently, both objectives are being strongly criticised, particularly by international lending agencies. Indeed, although electricity is a key factor in development, it can actually do little for economic development if transportation, banking and other infrastructure are not provided as well. Moreover, import substitution policies have shortcomings that are

limiting the flow of capital and technology to developing countries' utilities. Such arguments suggest that electrification policies should not have high priority, especially if subsidies are needed. Nevertheless, access to modern life is almost impossible without access to electricity. Governments are responsive to political pressures that come from areas not supplied with electricity and hence the development of the infrastructure of electricity supply remains a priority in all the developing regions that we have studied.

This main objective of widening access to electricity was pursued by developing country utilities until quite recently with relative success - if measured by the growing share of urban and rural populations supplied with electricity. Nevertheless, there is a substantial diversity of situations among developing regions. In Latin-America, urban populations are almost universally supplied with electricity and a substantial share of rural areas are electrified; large grids connecting the bulk of power generation capacity exist and several interconnections between neighbouring countries are in place as well. The quality of service that utilities provide is generally good although in the last few years problems of shortage and rationing have emerged in a few countries like Argentina.

The situation of Africa is radically different; excepting North Africa, where the ESI is in a similar situation to Latin-America, only a small share of the urban population is supplied with electricity and there is virtually no supply in the rural areas. National grids are rare, although several small networks covering a few large towns and surroundings do exist; interconnections with neighbouring countries are emerging but are still very limited. The quality of service that utilities provide is very poor.

North-east and South-east Asia are in a situation quite similar to that of Latin-America but Indochina is much more like Africa. India and China have developed large grids and supply electricity to large portions of urban and rural areas; the quality of service utilities provide is, however, very poor, and rationing of electricity supply and self-production is common.

These different situations lend to quite distinct objectives as far as electricity supply is concerned. In the case of Africa South-Sahara and Indochina, the challenge still is to increase substantially the share of

both the urban and rural population supplied with electricity. These countries have high rates of population growth and a very poor economic situation - which both, obviously, do not ease the task. Much can be done to improve efficiency and the financial conditions of utilities in these regions and such improvements will give many new consumers the benefit of electricity supply. It remains true, however, that without very substantial investments, these regions have little chance of changing the current situation of undersupply of electricity in the foreseeable future.

India and particularly China, where population growth is slowing down dramatically, are in a better position. Most of their urban population is supplied with electricity, although the majority of their huge rural populations are still waiting for electricity supply. The main concern of these countries is to rapidly increase electricity generation so as to eliminate both rationing and, especially in India, small, inefficient self-generation (although reinforcement of transmission and distribution lines is still necessary). Once again, much can be done to improve efficiency and financial conditions in utilities; in their case, the impact of these improvements on electricity supply will be more widely felt since a larger share of the population is already supplied. Nevertheless, ESI investments have to be maintained at a high level to provide a reasonable quality of service and to keep extending the supply of electricity.

In the remaining regions (Latin-America, North-Africa, North-East Asia and South-East Asia) urban populations are almost universally supplied with electricity, as well as a substantial share of rural areas. Efforts in these countries are concentrated on performance improvements, but since population is still growing, the development of electricity supply infrastructure cannot be neglected. In Mexico, for instance, the share of urban population supplied with electricity decreased recently as a result of rapid urbanisation and a slowing down in ESI investments.

B. Technological Capabilities

Nationalised utilities had to face a lack of domestic technological capabilities when they started to operate. Training of nationals, a first priority, was undertaken to reduce the shortage of skilled labour, and to improve domestic capabilities to operate and maintain power plants (user

capabilities). In larger countries, the building up of a domestic capital goods industry was fostered, using the purchasing power of domestic utilities to promote domestic supply of the ESI. Quite often this process developed in the framework of import substitution policies, and it was intended to improve capabilities to adapt, modify and eventually design power plants (design capabilities).

An assessment of current technological capabilities indicates that a diversity of situations has emerged in developing world. Africa South-Sahara and Indochina have acquired very limited user technological capabilities and have virtually no design capabilities. Indeed, in those regions, poor operation of both thermal and hydropower plants is still the rule and utilities rely on external expertise for project implementation. Latin-America is in a much better position, although in recent years some worrying signals have appeared that technological capabilities already acquired were apparently being lost. 'User capabilities for conventional technologies are fully acquired, although much effort has yet to be made in new technologies such as combined cycle, fluidised bed and nuclear. Large Latin-American countries have developed a substantial capacity to supply capital goods to the ESI, especially in hydro, but design capabilities for thermal power plants are limited and concentrated in Mexico. North-East Asia has also acquired full user capabilities in power plants, and most design capabilities as well. South-East Asia and North Africa have acquired substantial user capabilities but design capabilities are still incipient. China and India have extensive technological capabilities but they need to be substantially improved, since both performance and quality standards are still poor.

These rather poor technological capabilities in most developing regions is a major source of poor technological and economic performance of utilities. This is a long-standing problem for developing countries that in the past has been masked by the rapid diffusion of new vintages of more efficient electricity supply technologies. The interaction of financial crisis and the slow-down in electricity consumption has sharply reduced this diffusion process, and poor performance has become more obvious. This is a major weakness that substantially raises both investment and running costs, with obvious economic and social impacts. To a large extent, the over-concentration of developing countries' electricity technology policies

on the diffusion of new, imported vintages of technology has limited the role of incremental change and, in the process, the acquisition of domestic technological capabilities to adapt and modify electricity supply technologies.

Improvement of technological capabilities is a principal objective for developing country ESIs since it can reduce costs. In Africa South-Sahara and Indochina, efforts need to be concentrated on the improvement of user capabilities that will eventually lead to their becoming better informed buyers. In China and India, improvement of user capabilities is a priority but it must be connected to efforts to adapt and modify existing technologies; it will lead to incremental changes that are urgently needed to raise both performance and design capabilities to international standards. In South-East Asia, North-Africa and in most countries of Latin-America, the main concern is to develop design capabilities; North-East Asia and large Latin-American countries need to enhance their technological capabilities in design, especially as far as new technologies are concerned.

C. Financing

It is worth remarking, however, that electrification and acquiring technological capability both carry economic and financial costs. Indeed, the actual cost of policies adopted to achieve them has been very high and most utilities in developing countries are in no financial position to continue to invest in the development of electricity supply. The ability of developing country utilities to achieve the deep-rooted objective of providing electricity to every citizen in every region is in jeopardy, if not out of the question. This fundamental point has wide political and economic consequences which, to a large extent, explain the immense difficulties developing country utilities and governments alike are facing in deciding and enforcing policies that could eventually resolve the current financial stalemate in which most developing country utilities are trapped.

There are obvious underlying conflicts between the objective of providing cheap, reliable electricity universally, and the real economic situation of developing countries. From the macroeconomic point of view,

developing countries suffer from extreme scarcity of both capital and hard currencies, but electricity supply is capital intensive and demands large quantities of imports; from the microeconomic point of view, a large share of the population has no ability to pay the full costs of electricity supply. These conflicts were often overcome in the past with financial support from governments and international development and aid agencies, on the assumption that, first, productivity growth would solve the underlying conflicts in the long term, and second, that equity issues, particularly absolute poverty, had to be addressed anyway.

Unfortunately, the financial situation of the Treasuries of developing countries has deteriorated dramatically since the debt crisis started. Moreover, international agencies changed their approach to the development of electricity supply and their willingness to finance it was sharply reduced. The financial sources that supported the extension of ESI into new (particularly poor) areas of developing countries are therefore seriously limited for the time being. This situation requires a profound review of developing country electrification policies in order that the long-term objective of universal electricity supply can be made plausible.

The financial situations of utilities in different developing regions are quite distinct; therefore their ability to finance the development of ESI is also necessarily different. The North-East and South-East Asia utilities are in the unique position of being in a sound financial situation; no other developing region can claim to be similarly placed. Indeed, in North-East and South-East Asia, electricity prices are high enough to cover costs, and governments are able to provide financial resources to support investment. Nevertheless, electricity consumption is increasing at very high rates (over 10% in Thailand for instance): this requires enormous investments that can hardly be financed by utilities' internal funds and government support alone; loans and suppliers' credits are essential elements in these utilities' financial strategy, but they are increasingly difficult to find.

Latin-American utilities have a difficult short term financial situation but if sensible policies are introduced the region can quickly recover a sound financial position. Latin-American utilities have large debts, resulting in enormous financial costs and, although electricity

prices have been substantially increased in the last couple of years, in most cases they still do not cover full costs. Moreover, the situation of the virtual bankruptcy of governments allows no scope for Treasury support. It is true that the economic crisis has substantially reduced the rate of growth in electricity consumption, reducing the financial needs of utilities; nevertheless, they still depend heavily on increasingly scarce loans and credits in order to maintain electricity supply. North African utilities are in a similar situation.

China and India have a much more difficult situation in as much as huge investments have to be made to supply a still fast increasing consumption. Prices are substantially lower than costs and large government support and substantial economic aid have to supplement loans and suppliers' credits if the current problem of rationing is to be eventually resolved. Only Africa South-Sahara is in a worse situation; utilities have huge debts, prices are much below costs and government agencies are mostly not paying for their electricity supply. It is hard to imagine any sensible solution for the enormous financial problems of African utilities without very substantial economic aid and debt relief even in the undesirable scenario of electricity consumption growing quite slowly.

Although there is a diversity of financial situations among the utilities of developing regions, there is one similarity. Their ability to raise funds, particularly hard currencies, to finance their investment plans needs to be substantially enhanced. Governments and multilateral and bilateral financial sources are in no position to support the large investments that are still needed; therefore, new sources of financing need to be found if the objective of supplying electricity is to be achieved. Pressures are growing for a review of the institutional and regulatory framework of the ESI. This review, arguably, could offer a larger role to the private sector in order to enhance the ESI's ability to invest.

7.2 Key Issues

The 1980's were a turning point for developing countries' utilities as well for those in the industrialised countries. The historical trends of

improvement in both economic and technological performance were reversed, the financial situation of utilities deteriorated dramatically and environmental issues emerged. Politically difficult social and regional issues surfaced, as policies towards electricity supply had to be reviewed in order to postpone new supply and increase prices. Managements that used to make decisions on relatively sure assumptions about technology, costs, prices and electricity demand have had (and still have) enormous difficulties in adapting to the new circumstances of large uncertainties about the future.

A. Financial Crisis

The most pressing issue that ESIs in developing countries have to face is the financial crisis, since financial viability is a pre-condition for achieving the objectives set for utilities. The appalling situation of developing countries' public accounts leaves little if any scope for financial support from governments. Moreover, private banks and multilateral and bilateral financial sources are not prepared to lend to utilities in developing countries unless the utilities recover financial soundness. Developing country utilities therefore have to improve their financial situation, mainly by increasing their net revenues. This will improve both their self-financing ratio and, hopefully, the willingness of private capital either to invest directly or provide loans.

In Africa, and to a much lesser extent in Latin-America, utilities have large financial deficits because many consumers, especially government agencies, simply do not pay their electricity bills. Such an awkward situation is one manifestation of the economic crisis experienced by developing countries, but it is obviously untenable in the long term. Utilities must not be perceived as providers of free electricity for government, or other consumers will be sooner or later be penalised by much higher electricity prices.

Electricity prices quite often do not reflect real costs, in developing and industrialised countries; cross-subsidies are widely used to promote social, regional or sectoral policies. Although it can be argued that cross-subsidies distort markets, their effect on utilities' overall financial performance can be nil if average electricity prices cover

average costs. Unfortunately this is not the case in most developing countries where price distortions are so serious that it is impossible to match revenues to costs. In Africa, there are situations where electricity prices do not cover even fuel costs; in India and China, especially in rural areas, electricity prices are consistently much below actual costs; in Latin-America real electricity prices were reduced continuously after the oil crisis despite a trend of increasing long-run development costs.

This situation squeezes net revenues and quite often results in financial deficits. It is fair to say, however, that these problems are now recognised and pricing policies are changing in the developing world. In Latin-America the trend of declining real electricity prices has recently been reversed and the average price is increasing. Moreover, marginal cost pricing approaches have been used to introduce a pricing structure that can now better inform consumers about the real cost of supplying them. Utilities are increasingly getting a fair chance to recover financial soundness. It is possible to identify trends of this sort in Africa, India and China although the extent of change is perhaps more marginal.

The increase in net revenues will improve the economic and financial situation of developing country utilities; nevertheless, the problem of financing investment remains since developing country utilities can, even optimistically, only self-finance around 40% of their investment, and support from both government and multilateral and bilateral financial sources is likely to be limited. This situation has stimulated a growing movement in developing countries to giving a larger space for private capital in the ESI, an idea that emerged in industrialised countries and is strongly supported by multilateral financial sources. In Latin-America, new governments are considering privatising the ESI but have not clarified as yet the exact role the private sector is supposed to play; in Asia and Africa, private capital is being invited to play a significant role in electricity generation through mechanisms that are not as yet fully established.

B. Sustainability

Financial viability conflicts with other objectives such as improvement in the balance of payments, social equity, environmental soundness and regional development. This is not a problem specific to

developing countries, as the British privatisation of the ESI is highlighting. There, large substitution from domestic coal to imported coal, natural gas (or both) is likely to occur soon after privatisation is complete. Government provisions have had to be made to ensure a high level of domestic coal use by the privatised British utilities, so avoiding some of the regional social (and economic) impacts of the underlying policy. Developing countries must necessarily be much more careful with their policies since their regional and social disparities are much larger, and their technological and economic capabilities much more limited.

Three particular issues deserve attention in relation to these conflicts of objectives. First, rural electrification is likely to suffer most from the move towards improving the financial situation of utilities. Strategies towards rural development must be reviewed and possible energy alternatives to utility electricity supply must be considered. It is worth remarking that this issue is especially pressing in the poorer developing countries, since in their case rural electrification is as yet negligible. Second, the difficult financial situation of utilities and high interest rates are likely to induce technological choice towards less capital intensive technologies. Fossil fuel thermal power plants, consuming tradeable energy sources will be chosen instead of hydropower, a non-tradeable energy source. For countries with large external debts and deficits on their trade balance, this can be a serious problem. Third, environment is likely to be neglected by utilities keen to solve their financial crisis as quickly as possible, although there are clear signs that developing country utilities are increasingly integrating environmental concerns in their decision making process. These issues indicate that there is a trade off between utilities' financial viability and social, economic and environmental objectives which has to be carefully assessed.

C. Innovation

The quality of service developing countries' utilities provide is deteriorating rapidly. These problems are largely the result of the financial crisis, although management and government policies responsibilities must not be discounted. Long established ideas about trends in electricity markets and technologies compounded by an inability

to understand the profound impact that changes in the macroeconomic environment would have on the development of ESI, has led to a defensive, conservative approach by utilities to electricity policies. Eventually, cuts in investment became unavoidable but they severely unbalanced the structure of electricity supply and caused large economic and technological inefficiencies.

The financial crisis, a short-term problem, is to a large extent overshadowing technological opportunities which have a large potential to reduce costs and, consequently, increase net revenues. Interconnection of both domestic and neighbouring countries' grids is a policy that can dramatically improve economic performance of utilities in Africa and, to a lesser extent, in Asia and Latin-America as well. Interconnection would substitute lower cost hydropower for old, inefficient, unreliable and costly diesel power plants in Africa; and it would substitute lower cost hydropower for old, expensive thermal power plants in Asia and Latin-America. Moreover, reserve margins - which amount to almost 90% in Africa, 43% in Asia and 44% in Latin-America - could be considerably reduced, thereby reducing capital costs.

In developing countries, no serious attention has yet been given to end-use electricity conservation policies. Only Brazil seems to have taken significant but as yet timid actions to improve the efficiency of electricity end-uses, although there are clear indications that policies of electricity conservation can reduce electricity demand substantially in developing countries as well as in industrial countries. Co-generation, a major opportunity to improve energy efficiency and reduce utilities' investments in power generation has equally received no serious attention; in fact, utilities are very reluctant to give any room for co-generators in electricity supply despite (in some cases obvious) benefits for consumers. The financial crisis has led to a generalised neglect of maintenance routines that has worsened the technological performance of both generation and transmission/distribution. In some cases, the deterioration in equipment has been such that rehabilitation has become a necessary policy.

D. Management

The deterioration of utilities' economic performance after the oil crisis is not a problem specific to developing countries. Indeed, some

utilities in industrialised countries have had serious financial problems that have generally been solved with a level of government financial support that has not, unfortunately, been available in developing countries. The new environment that we described in Chapter 2 has been very demanding on management of developing country utilities; from one side, management had to cope with escalating costs and large uncertainties, and from another it had to cope with government policies that have tried to limit the social and economic effects of the energy and financial crisis. Accustomed to making decisions on the assumption of a relatively certain future, and adapted to assume that the macro-economic impacts of electricity supply were necessarily positive, utilities' management has had immense difficulty in resisting government policies that have eventually proved to be extremely harmful to the financial performance of utilities. Centralisation and monopoly power, which in the past were sources of effectiveness, suddenly became sources of inefficiency. Poor management decisions were immediately echoed by the entire economy, since electricity is a pervasive commodity.

Since the oil crisis, management approaches to the ESI have been under profound review in industrialised countries. Assessment of macro-economic and environmental impacts of electricity projects, planning in the presence of uncertainties, pricing strategy and management of electricity demand are all new skills that management has had to acquire in industrial countries. These skills are as yet scarce in developing countries, where old approaches are still in current use. For instance, most forecasts of electricity demand in developing countries still do not assess the effects of price on demand; unsurprisingly, they consistently over-estimate actual consumption. A substantial effort in management training seems to be essential.

E. Regulation

So far we identified the financial crisis, conflicts in objectives acquisition of technological capabilities and improvement of managerial skills as key issues that ESIs in developing countries have to face. Although the financial crisis is the most pressing issue, there are obvious interactions between these issues. Poor managerial skills are a source, for instance, of unsatisfactory maintenance routines and unsuitable

pricing policies that both result in financial deficit. Indeed, it is hard to imagine that financial soundness can be recovered without substantial improvement of utilities' economic and technological performance.

Some argue that the source of all these problems is a "monolithic state controlled" ESI that avoids competition and gives room for government interference in management decisions. They suggest that profound institutional changes must be introduced and that the ESI should be sold off to the private sector (as some developing countries are intending). Privatisation would bring market forces to the industry and promote both decentralisation and competition. However, the experience of privatisation in industrialised countries indicates, so far, that although government interference can be limited, it can not simply be abolished; moreover, it shows that competition is necessarily limited. Indeed, electricity supply has far-reaching social and economic implications, especially in developing countries; besides, it has technical characteristics which predominantly induce collusion rather than competition in pursuit of economic efficiency. Governments of developing countries certainly need to improve on their past record in intervening in their ESIs. However, this needs to be done not by withdrawal of state involvement, but rather by a continuous monitoring of the widely ramifying impacts of electricity supply and the development of guidelines for the strategic development of the ESI.

In the process of pursuing these improved roles in relation to the ESI, developing country governments need to give more attention to the fundamental issue which the financial crisis, and the consequent emphasis on privatisation, has eclipsed: regulation. The role of the regulator can be that of an intermediary between government and utilities, ensuring that utilities follow strategic governmental directions while protecting utilities from day-to-day political interference. The context within which utilities have to operate has radically changed in the last two decades but the regulatory regime has not, essentially, been modified in developing countries, despite an emerging trend towards privatisation. For instance, there are still large restrictions on power generation by non-utility producers and this limits the development of efficient co-generation; there are regulations on capital goods imports that restrict competition and increase investment costs; decision-making is still centralised, hindering the development of efficient end-use technologies. These few examples point to the urgent need for a new regulatory regime.

Although regulations are necessarily country specific, there are a few points that a new regulatory regime should address. First, management should be put at an arm's length from government, although it must agree to pursue broad economic and social goals. It should be able to avoid political interference in its day-to-day operation but its accountability should be improved. The concept of "contrat-plan" already in use in some developing countries of Africa is a substantial step forward. Second, some level of decentralisation of ESI should be introduced (at least in the larger countries) to improve flexibility, and also competition where possible and desirable. The idea of opening the grid for direct contracts between electricity suppliers and consumers seems to be the most likely to produce substantial results. Third, private capital should be offered a fair opportunity to participate in the ESI in order to increase the financial resources available for investments. Fourth, there needs to be a strong regulatory body, independent of government interference. The regulator can fix and monitor standards, enforce competition and supervise costs and prices.

The dichotomy between privatisation and state control is a mistaken one. Developing countries should rather look for a rational balance between public and private ownership, but most importantly under a new regulatory regime. Industrial country experience suggests that progressive reforms rather than radical solutions is the best way to search for that balance. The policies needed are usually controversial and sometimes painful: what is needed is a less short-term approach, which will allow the possibilities of winning political acceptance.

CHAPTER 8 CONCLUSIONS

Our report has shown that although the objectives and issues facing the ESI in developing countries are similar there is a diversity of situations between regions. Electrification, improvement of technological capabilities and better financing are common objectives; financial crisis, sustainability, innovation, management and regulation are common issues; but they take different shapes in each developing region. This diversity requires some differentiation in policies. To state it baldly, it is not possible to tackle the financial and technological problems of Sahelian and South-East Asian countries with the same policies. This may seem rather obvious; nevertheless, statements about the situation and policies for the ESI of developing countries are quite often made without any such distinctions.

Our report has also shown that there is common ground between the perceptions of Northern financial institutions and those of Southern policy-makers about the problems and issues that the ESIs of developing countries have to face. There is, however, a fundamental disagreement about diagnosis of these problems, and one that eventually results in different priorities. The North tends to argue that problems have their origin in poor utility performance which has resulted in financial disarray; it gives first priority to the issue of financial viability in its proposed reforms. The South by contrast, argues that the origin of problems is the debt crisis which has undermined utilities' performance; and only then did utility financial problems emerge; it is unwilling to accept that the financial problems of utilities can be solved without a solution to the debt problem, although it is prepared to introduce reforms in ESI.

These are important points, full of consequences. The North tends to take an overly narrow view of the ESI and its role in economic development. It has little concern for the conflicts between financial viability and equity issues; it presses for privatisation to recover the ability of developing countries' ESIs to invest, and it is prepared to postpone the objective of providing electricity to every region and all citizens. The

south on the other hand, perceives the ESI as a strategic infrastructure for economic development. It has a clear understanding of the difficult social and political implications of postponing electricity supply and, although prepared to leave room for the private sector in ESI, it is unwilling to introduce reforms which jeopardise its objectives.

Our findings have policy implications for both developing and industrialised countries. For developing countries the policy implications of our findings can be grouped under four main heads:

A. Financial Viability

The ESI must recover its ability to invest, otherwise it cannot achieve its objectives. There are no simple, easy solutions to this problem however. The self-financing ratio of utilities must be increased substantially to reduce external financial needs. To this end, a profound review of pricing policy is unavoidable. Where necessary, prices should be increased to produce an operating surplus; average prices must more than cover average costs, although prices should accommodate equity objectives and regional policies. Private capital should be offered room in the ESI. Technological change can make it possible to accommodate private capital without concessions on ESI objectives.

B. Innovation

The technological performance of developing countries' utilities can and must be substantially improved. Much more output can be secured from existing installed capacity if innovation policies are oriented to incremental rather than radical change. Interconnexion of both domestic and international grids offers major opportunities to reduce reserve margins, improve reliability and diminish the running costs of utilities. Rural electrification can be significantly enhanced if standards are reviewed to accommodate less expensive technologies. Electricity conservation and cogeneration can both be a substantial source of efficiency if energy technological capabilities are disseminated more widely through firms.

C. Sustainability

The economic, social and environmental impacts of electricity supply have to be carefully assessed. Higher interest rates and shorter payback periods for investment are already inducing a shift from hydropower towards thermal power. This will have major impact on electricity prices, on the trade balance and on the environment. Tradeable energy sources will substitute for non-tradeable; fossil fuel will substitute for renewable energy. The long term is being sacrificed to the short term by a higher discount rate. There is a trade off between short term financial constraints and long term economic, social and environmental sustainability that has to be carefully resolved.

D. Regulation

The regulatory regime under which utilities operate has to be reviewed. A strong, independent regulatory body which will ensure that utilities follow clear guidelines fixed by government, but will provide enough scope for utilities to run their business on sound financial lines is likely to produce the best results. It will protect consumers from utilities' monopolistic power and it will offer a fair opportunity to independent producers of power to sell their electricity; it will encourage competition whenever possible and desirable.

For industrialised countries the policy implications can be grouped under four main heads:

A. Financing and Aid

The financial problems of developing countries must be seen in the wider context of general indebtedness rather than in terms of responses that utilities can make alone. Much that is written by northern financial institutions neglects the role they played in the uncritical expansion of credit in the 1970's, an expansion that has led to today's debt. The Director of the IMF recognised this element of responsibility when he recently urged developing countries to concern themselves with sovereign debts rather than give priority to debt service obligations to private foreign banks. In this context, it is worth remembering that the purpose

of the World Bank at its original conception was to compensate for the inadequacies of private capital markets: to provide project funding for activities that show good rates of return in the long term although they were unattractive to private capital; to compensate for the boom and bust cycles that private capital markets have exhibited a number of times over the past hundred years in financing activities in the South; and to provide longer term finance for infrastructural investments than private capital was likely to offer. In a more concrete and specific area, it is worth stressing again that there is much to be said for Northern agencies paying more attention in their future funding activities to the issue of domestic and international interconnexion, where modest expenditures may yield high returns.

B. Sustainability

The current trend to short term financing at high interest rates is unsuitable for the protection of the environment and will aggravate potential shortages in the fuels market. Fossil fuel plants with high running costs (and thereby higher electricity prices) but lower investment costs will replace hydropower plants. The World Bank and other multilateral and bilateral agencies should resist the pressure to worsen the terms of finance offered to developing countries and should help alleviate the problems associated with private capital flows.

C. Technological Cooperation

Industrialised countries will continue to play a major role in the transfer of technology and know-how to the power sectors of developing countries. But this transfer must go beyond the mere sale of hardware and technical assistance; it must combine commercial and official finance in packages that are explicitly designed to improve the technological capabilities of recipients to buy, operate, maintain and incrementally improve imported power equipment. Funding agencies must abandon their narrow project focus and take a longer term perspective to build local capabilities. This more strategic approach would involve the development of expertise among local people and reduce the current excessive dependence of aid agencies on expatriate personnel; it would involve the sequencing of power investment and explicit investments to capture the maximum "learning

effects" that can be gained from experience. It would take steps to reduce the effects of current aid practices which subsidise capital but increase the scarcity of funds for recurrent expenditures.

D. Institutional Reform in Developing Countries

The North has experimented with a range of reforms to its own ESIs in the last decade. In one case (Britain), this has involved thoroughgoing privatisation and the maximisation of competition: elsewhere, ownership changes have been much more limited and the major single focus has been less on fundamental structure and ownership changes than on developing new regulatory structures which allow more access to non-utility producers and, partly as a consequence of this, some competition at the margins of the ESI. It is important that in its attempts to influence the South, the North should not misinterpret its own experience.

Privatisation as such has been limited in scope and is proving difficult to implement. At the same time, the underlying organising principle of virtually all ESIs, seems likely to remain cooperation not competition. What industrialised countries have begun to do more widely - and their experience suggests that versions of such change may be appropriate for many parts of the Third World - is to regulate their ESIs more transparently, irrespective of ownership, and to loosen the monopolistic hold on production that utilities have traditionally had. This is, in the North, beginning to allow new (usually private) generators into the public supply system.

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Table 1: Key Energy Characteristics of World Regions (1987)					
Regional Percent of Developing Countries:	Population (mill)	GDP (bill.US\$)	Energy Consumptio (mill.TOE)	Electricity Production (TWH)	
Latin America (%)	11.00	31.00	24.60	26.80	
Asia (%)	69.50	40.20	56.90	56.30	
Africa (%)	15.00	11.00	7.20	6.70	
Middle East (%)	4.30	17.60	11.10	9.90	
Sample (%)	60.30	49.40	63.70	56.80	
OECD (%)	21.60	366.20	167.70	319.00	
EEC (%)	8.60	138.60	44.60	84.90	
Regional totals:					
Developing Countries	3736.70	2345.70	1634.80	1953.60	
sample	2253.20	1158.80	1041.40	1109.60	
oecd	808.10	8589.50	2742.20	6232.30	
eec	322.10	3252.30	728.90	1659.20	
Sources:					
	World Bank (Population and GDP)				
	IEA (Energy and Electricity)				

Table 2

Per Capita Energy and GDP Figures (1987)

	GDP	Modern Energy Consumption	Electricity Production	
	(US\$/capita)	(KEP/capita)	(TWH/capita)	
Argentina	2390	1031	1671	
Brazil	2020	582	1431	
Mexico	1830	946	1176	
China	250	451	465	
India	300	122	273	
Thailand	850	265	535	
Algeria	2680	492	604	
Ivory Cst	740	95	180	
Libi	210	17	22	
Senegal	520	106	107	
Maire	150	42	142	
Developing Countries	6269	349	525	
OECD	9408	2947	1296	
EEC	9904	4419	1941	
Sources:				
World Bank (GDP)				
IEA (Electricity, Production and Modern Energy Consumption)				

[illegible]

Primary Energy Production, Requirements and Consumption (thousand TOE)
Trends by Major World Region

Primary Energy Production

Region	1971	1975	1980	1985	1986	1987
Africa	329396	316759	415266	430594	430169	434761
Latin Am	317866	299352	415127	501070	505656	520393
Asia	399793	544044	717327	953635	987335	1025791
Middle Eas	847842	1030743	995894	606847	726632	744958
EC	354910	390050	509720	610370	620310	620770
ECD	2171790	2262500	2610420	2865260	2874900	2939570
World						

Primary Energy Requirements

Region	1971	1975	1980	1985	1986	1987
Africa	82217	105929	148508	194763	196644	204516
Latin Am	185478	244565	334705	373157	382429	401772
Asia	421016	543736	735322	938471	994081	1041330
Middle Eas	52432	75849	123462	191072	201332	213861
EC	885660	997360	1055590	1051000	1070330	1090580
ECD	3178200	3380730	3739750	3743500	3776890	3886840
World						

Total Final Energy Consumption

Region	1971	1975	1980	1985	1986	1987
Africa	53785	68896	90964	109920	109862	112442
Latin Am	124878	167673	228120	250896	260084	272838
Asia	338788	422260	572916	724680	759846	789580
Middle Eas	34470	55135	81991	129957	134609	142339

EEC	668740	742510	771300	756800	771130	72
OECD	2396990	2494100	2685000	2641150	2664730	27
World						
Surplus (Deficit) Primary Energy Production						
Region	1971	1975	1980	1985	1986	
Africa	247179	210830	266758	235831	233525	23
Latin Am	132388	54787	80422	127913	123227	11
Asia	(21223)	308	(17995)	15164	(6746)	(1
Middle Eas	795410	954894	872432	415775	525300	531
EEC	(530750)	(607310)	(545870)	(440630)	(450020)	(469
OECD	(1006410)	(1118230)	(1129330)	(878240)	(901990)	(947
World						

Primary Energy Production, Requirements and Consumption (thousand TOE)
Trends by Sample Countries

Sample Country	1971	1975	1980	1985	1986	1987
Algeria	39919	58446	66222	83059	85113	90337
Cote d'Ivoire	31	86	378	1627	1624	1154
Senegal	-	-	-	-	-	-
Argentina	28528	29398	38435	44436	44071	47126
Brazil	20454	27438	44659	82499	83407	85103
Mexico	35736	55520	135946	184679	171599	178831
China	243461	333916	439006	592417	601034	626295
India	51558	67991	80089	122816	132239	138209
Thailand	573	887	710	7149	7529	8659
Mali	-	3	6	10	10	-
Zaire	-	392	1413	1663	1324	

Primary Energy Requirements

Sample Country	1971	1975	1980	1985	1986	1987
Algeria	3684	6056	12374	19783	21019	21149
Cote d'Ivoire	892	1202	1608	1479	1418	1452
Senegal	518	665	872	855	898	940
Argentina	31630	34757	41176	43278	45141	49839
Brazil	41629	65176	92641	108127	115781	118915
Mexico	35932	52872	88425	105348	100259	106319
China	241446	321385	423536	539838	567673	593548
India	66830	80803	100080	135099	147667	153609
Thailand	6860	8893	12417	16273	16984	19516
Mali	-	-	-	-	-	-
Zaire	-	-	-	-	-	

Total Final Consumption						
Sample						
Country	1971	1975	1980	1985	1986	19
Algeria	2357	3707	6527	10386	11102	113
Cote d'Ivo	717	936	1189	982	984	10
Senegal	407	480	701	686	721	7
Argentina	21260	23553	27867	27821	28769	320
Brazil	29606	46827	66108	72237	79282	822
Mexico	27591	39645	62174	76200	74099	774
China	200091	257367	351119	448941	468318	4816
India	48411	56560	67271	87589	92706	967
Thailand	5449	7077	9495	12076	12807	141
Mali	-	104	128	139	131	-
Zaire	-	1166	1299	1292	1380	
Primary Energy Production - Primary Energy Requirements						
Sample						
Country	1971	1975	1980	1985	1986	19
Algeria	36235	52390	53848	63276	64094	6918
Cote d'Ivo	(861)	(1116)	(1230)	148	206	(29
Senegal	(518)	(665)	(872)	(855)	(898)	(9
Argentina	(3102)	(5359)	(2741)	1158	(1070)	(271
Brazil	(21175)	(37738)	(47982)	(25628)	(32374)	(3381
Mexico	(196)	2648	47521	79331	71340	7251
China	2015	12531	15470	52579	33361	3274
India	(15272)	(12812)	(19991)	(12283)	(15428)	(1540
Thailand	(6287)	(8006)	(11707)	(9124)	(9455)	(1085
Mali	-	-	-	-	-	-
Zaire	-	-	-	-	-	-

Comparative Electricity Generation

Electricity Generation Trends in Major World Regions (Gwh)

Region	1971	1975	1980	1985	1986	1987
TOTAL						
Latin America	163593	229507	362597	474784	500868	524840
Africa	36634	53591	100136	122878	128263	132740
Asia	293654	418685	641862	928900	1007488	1100860
Middle East	27333	46054	95480	172714	183885	195184
Dev. Countries	521214	747837	1200075	1699276	1820504	1953624
Total Sample	320210	848719	685034	965489	1036831	1110728
OECD	3593502	4276968	5237971	5903183	5983415	6232306
EC	984515	1137357	1403087	1572583	1612959	1659239
World	5263722	6522846	8315652	9841075	10115366	10579699

Region	1971	1975	1980	1985	1986	1987
THERMAL						
Latin America	74124	92945	137271	151120	170664	185984
Africa	12982	19616	39936	73789	78780	86494
Asia	205577	297239	470249	653354	704291	783506
Middle East	23564	40593	85168	160777	172155	180498
Dev. Countries	316247	450393	732624	1039040	1125890	1236482
Total Sample	194424	262202	406511	567663	577920	709248
OECD	2616924	2938442	3554820	3515399	3496246	3661673
EEC	781804	881571	1048043	901989	909529	932163
World	3897746	4649830	5800021	6281810	6421443	6736230

Region	1971	1975	1980	1985	1986	1987
HYDRO						
Latin America	89469	134045	222986	314798	324369	331497

Comparative Electricity Generation

Africa		23652	33975	60200	49089	49483	4
Asia		86784	118214	156786	224608	242452	23
Middle East		3769	5459	10312	11937	11730	1
Devg. Countries		203674	291693	450284	600432	628034	60
Total Sample		124576	181353	277982	384973	398297	38
OECD		873289	1006142	1082372	1176130	1174486	117
EEC		151058	161856	186554	183191	177890	18
World		1254890	1489405	1802108	2067310	2096058	210
NUCLEAR							
Region		1971	1975	1980	1985	1986	
Latin America		0	2517	2340	8866	5835	
Africa		0	0	0	0	0	
Asia		1293	3232	14827	50938	60745	7
Middle East							
Devg. Countries		1293	5749	17167	59804	66580	8
Total Sample		1189	5144	5341	13853	10858	1
OECD		103289	332384	600779	1211654	1312683	139
EEC		48989	91447	166117	484654	522640	53
World		111086	383614	713523	1491955	1597865	170

Comparative Electricity Generation

Electricity Generation Trends in Sample Countries (Gwh)

Region	1971	1975	1980	1985	1986	1987
Argentina	23624	29343	34706	45265	48821	51960
Brazil	51592	78936	139485	192731	201618	202286
Mexico	28483	440879	61868	85352	89383	96310
China	138400	195840	300630	410700	449571	497321
India	66384	85926	119260	188479	201609	217500
Thailand	5225	8866	15112	24179	25482	28652
Nigeria	2279	3630	7123	11274	12981	13947
Cote d'Ivoire	588	962	1744	2022	1817	2000
Senegal	348	445	636	704	758	752
Yali*	57	92	110	168	172	
Yaire*	3230	3800	4360	4615	4619	
Total Sample	320210	848719	685034	965489	1036831	1110728

Region	1971	1975	1980	1985	1986	1987
Argentina	21935	21446	21973	18555	21788	23590
Brazil	6734	4643	6351	6958	13630	12137
Mexico	14214	25345	44213	57624	57624	73692
China	108400	150840	242420	318330	318330	397094
India	37161	49988	69702	132544	132544	163248
Thailand	3177	5467	13839	20487	19928	24577
Nigeria	1899	3302	6866	11628	12731	13448
Cote d'Ivoire	449	579	391	664	410	710
Senegal	348	445	636	704	758	752
Yali*	29	53	60	34	42	
Yaire*	78	94	60	135	135	
Total Sample	194424	262202	406511	567663	577920	709248

HYDRO

Comparative Electricity Generation

		1971	1975	1980	1985	1986	
Argentina		1689	5360	15393	20944	21322	21
Brazil		44858	74293	133134	182673	187864	189
Mexico		14269	15534	17655	27728	23270	21
China		30000	45000	58210	92370	100227	100
India		28034	33311	46557	50948	53789	48
Thailand		2048	3399	1273	3692	5554	4
Algeria		330	328	257	646	250	
Cote d'Ivoire		139	383	1153	1358	1407	1
Senegal							
Mali*		57	39	50	134	130	
Zaire*		3152	3706	4300	4480	4484	
Total Sample		124576	181353	277982	384973	398297	388

NUCLEAR

Region		1971	1975	1980	1985	1986	
Argentina			2517	2340	5766	5711	
Brazil					3100	124	
Mexico							
China							
India		1189	2627	3001	4987	5023	
Thailand							
Algeria							
Cote d'Ivoire							
Senegal							
Mali*							
Zaire*							
Total Sample		1189	5144	5341	13853	10858	709

* Source UN Statistics

INCREMENTAL INCREASE IN ELECTRICITY GENERATION (TWh)

		1980/71	1987/80
A. Countries	Total	678861	753549
	Thermal	416197	503858
	Hydro	246610	181300
	Nuclear	15874	68391
B. Developing Countries	Total	364824	425694
	Thermal	212087	302737
	Hydro	153415	110814
	Nuclear	4152	7343
C. Developed Countries	Total	1644469	994335
	Thermal	937896	106853
	Hydro	209083	92200
	Nuclear	497490	795282
D. World	Total	418572	256152
	Thermal	266239	-115880
	Hydro	35496	-890
	Nuclear	117128	372114
E. Total	Total	3051930	2264047
	Thermal	1902275	936209
	Hydro	547218	302292
	Nuclear	602437	1025546

Energy Trends for ARGENTINA:					
	>1	>2	>3		
Year	Population	GDP	GDP/capita	Energy	
1970	23.7	65837	2777.93	22045	
1975	25.7	75681	2944.78	25125	
1980	27.9	84989	3046.21	29419	
1985	30.6	74479	2433.95	28751	
1990	32.9	93699	2847.99	36260	
1995					
2000	37.2	138697	3728.41	49684	
	[mill]	[mill US\$]	[US\$/cap]	[TOE:000's]	
	>4		>5	>6	>7
Year	energy/cap	Electricity	elec/cap	energy/GDP	elec/GDP
1970	930.16	17.87	754.09	334.84	27.14
1975	977.62	24.73	962.37	331.98	32.68
1980	1054.44	32.88	1178.63	346.15	38.69
1985	939.57	37.95	1240.22	386.02	50.95
1990	1102.12	48.58	1476.8	386.98	51.85
1995					
2000	1335.59	88.82	2387.63	358.21	64.03
	[KOE]	[TWH]	[KWH/cap]	[KOE/US\$]	[KWH/US\$]

Trends for Brazil:					
	>1	>2	>3		
	Population	GDP	GDP/capita	Energy	
1970	95.8	90600	945.72	54973	
1975	108.1	147700	1367.59	73842	
1980	121.3	208000	1714.75	89935	
1985	135.6	226600	1671.09	93011	
1990	150.4	314900	2093.75		
1995					
2000	179.5	561300	3127.01		
	[mill]	[mill US\$]	[US\$/cap]	[TOE:000's]	
	>4		>5	>6	>7
	energy/cap	Electricity	elec/cap	energy/GDP	elec/GDP
1970	573.83	38.2	398.74	606.76	42.16
1975	683.72	69.8	646.29	499.94	47.25
1980	741.42	122.8	1012.36	432.37	59.03
1985	685.92	172.6	1272.86	410.46	76.16
1990		202.4	1345.74	0	64.27
1995					
2000		364	2027.85	0	64.84
	[KOE]	[TWH]	[KWH/cap]	[KOE/US\$]	[KWH/US\$]

Energy Trends for MEXICO:					
	>1	>2	>3		
Year	Population	GDP	GDP/capita	Energy	
1970	51.17	93867	1834.19	36294	
1975	60.15	127941	2126.91	50415	
1980	69.39	175918	2535.11	71384	
1985	78.99	193621	2451.03	84808	
1990	89.01				
1995					
2000	37.21	138697	3728.41	49684	
	[mill]	[mill US\$]	[US\$/cap]	[TOE:000's]	
	>4	>5	>6	>7	
Year	energy/cap	Electricity elec/cap	energy/GDP	elec/GDP	
1970	709.19	26.03	508.63	386.65	27.73
1975	838.11	40.87	679.57	394.04	31.95
1980	1028.69	61.86	891.56	405.77	35.16
1985	1073.57	85.35	1080.46	438.01	44.08
1990					
1995					
2000	1335.59	88.82	2387.63	358.21	64.03
	[KOE]	[TWH]	[KWH/cap]	[KOE/US\$]	[KWH/US\$]

Trends for China:					
	>1	>2	>3		
	Population	GDP	GDP/capita	Energy	
1970	829.92	81336.20	98.00	191710	
1975	924.20	115868.20	125.37	299850	
1980	987.05	180212.50	182.58	402560	
1985	1050.44	291756.10	277.75	515100	
1990	1126.00	430541.10	382.36	660170	
1995					
2000	1278.00	789392.90	617.68	947150	
	[mill]	[mill US\$]	[US\$/cap]	[TOE:000's]	
	>4		>5	>6	>7
	energy/cap	Electricity	elec/cap	energy/GDP	elec/GDP
1970	231.00	115.90	139.65	2357.01	142.49
1975	324.44	195.80	211.86	2587.85	168.99
1980	407.84	300.60	304.54	2233.81	166.80
1985	490.37	410.70	390.98	1765.52	140.77
1990	586.30	636.70	565.45	1533.35	147.88
1995					
2000	741.12	1200.00	938.97	1199.85	152.02
	[KOE]	[TWH]	[KWH/cap]	[KOE/US\$]	[KWH/US\$]

Energy Trends for India:					
	>1	>2	>3		
Year	Population	GDP	GDP/capita	Energy	
1970	551.30				
1975	603.46	136907.00	226.87	58002	
1980	675.16	161703.00	239.50	70747	
1985	750.86	211602.00	281.81	87525	
1990					
1995					
2000	1002.00				
	[mill]	[mill US\$]	[US\$/cap]	[TOE:000's]	
	>4		>5	>6	>7
Year	energy/cap	Electricity	elec/cap	energy/GDP	elec/GDP
1970		55.83	101.27		
1975	96.12	79.23	131.29	423.66	57.87
1980	104.79	110.84	164.17	437.51	68.55
1985	116.57	170.30	226.81	413.63	80.48
1990					
1995					
2000					
	[KOE]	[TWH]	[KWH/cap]	[KOE/US\$]	[KWH/US\$]

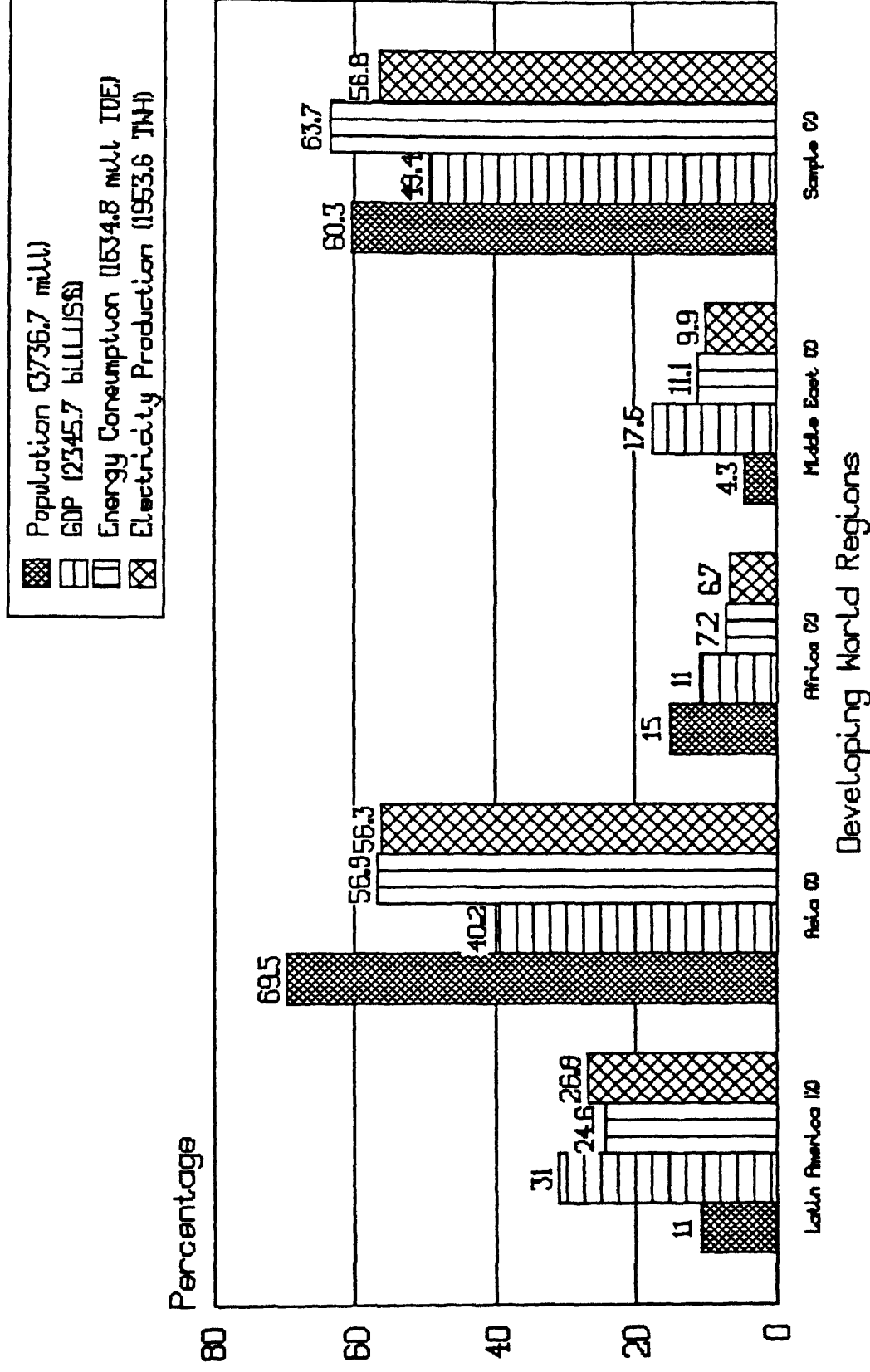
Energy Trends for Thailand:

	>1	>2	>3		
Year	Population	GDP	GDP/capita	Energy	
1970	35.55	7075.60	199.03	12286	
1975	42.39	14971.30	353.17	12691	
1980	46.96	32311.50	688.05	15231	
1985	51.80	37487.00	723.74	18554	
1990	57.20				
1995					
2000	64.39				
	[mill]	[mill US\$]	[US\$/cap]	[TOE:000's]	
	>4		>5	>6	>7
Year	energy/cap	Electricity	elec/cap	energy/GDP	elec/GDP
1970	345.60	4.41	123.93	1736.39	62.27
1975	299.38	8.44	199.09	847.69	56.37
1980	324.33	14.43	307.19	471.38	44.65
1985	358.21	23.07	445.49	494.94	61.55
1990					
1995					
2000					
	[KOE]	[TWH]	[KWH/cap]	[KOE/US\$]	[KWH/US\$]

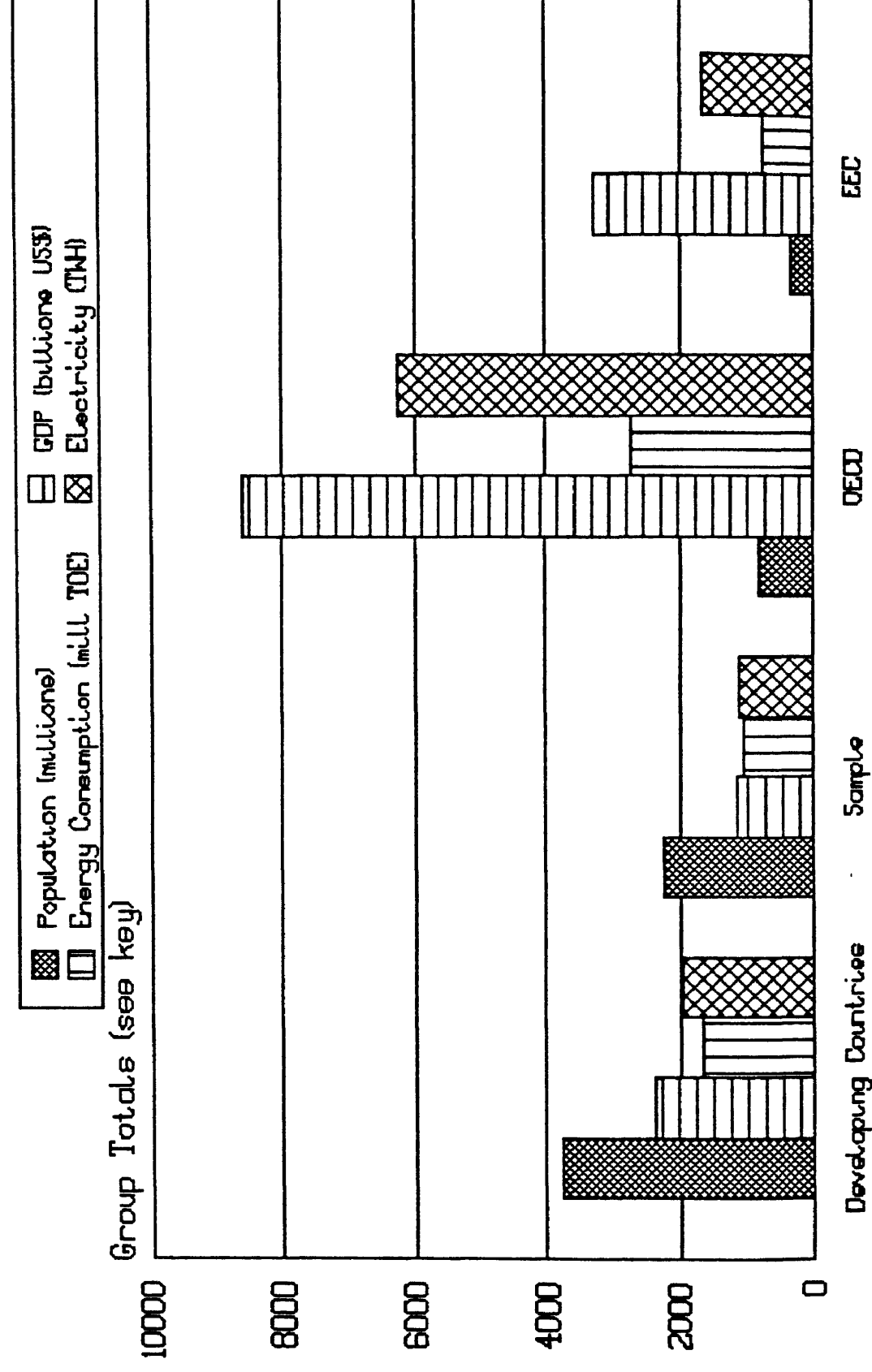
Energy Trends for EEC Countries:					
	>1	>2	>3		
Year	Population	GDP	GDP/capita	Energy	
1970	305.60	2364930.00	7738.65	668740	
1975	321.40	2641070.00	8217.39	742510	
1980	317.90	3053190.00	9604.25	771300	
1985	322.10	3252320.00	10097.24	756800	
1990					
1995					
2000					
	[mill]	[mill US\$]	[US\$/cap]	[TOE:000's]	
	>4		>5	>6	>7
Year	energy/cap	Electricity	elec/cap	energy/GDP	elec/GDP
1970	2188.29	984515.00	3221.58	282.77	416.30
1975	2310.24	1137357.00	3538.76	281.14	430.64
1980	2426.23	1403087.00	4413.61	252.62	459.55
1985	2349.58	1572583.00	4882.28	232.70	483.53
1990					
1995					
2000					
	[KOE]	[TWH]	[KWH/cap]	[KOE/US\$]	[KWH/US\$]

Key Characteristics of Developing World Regions

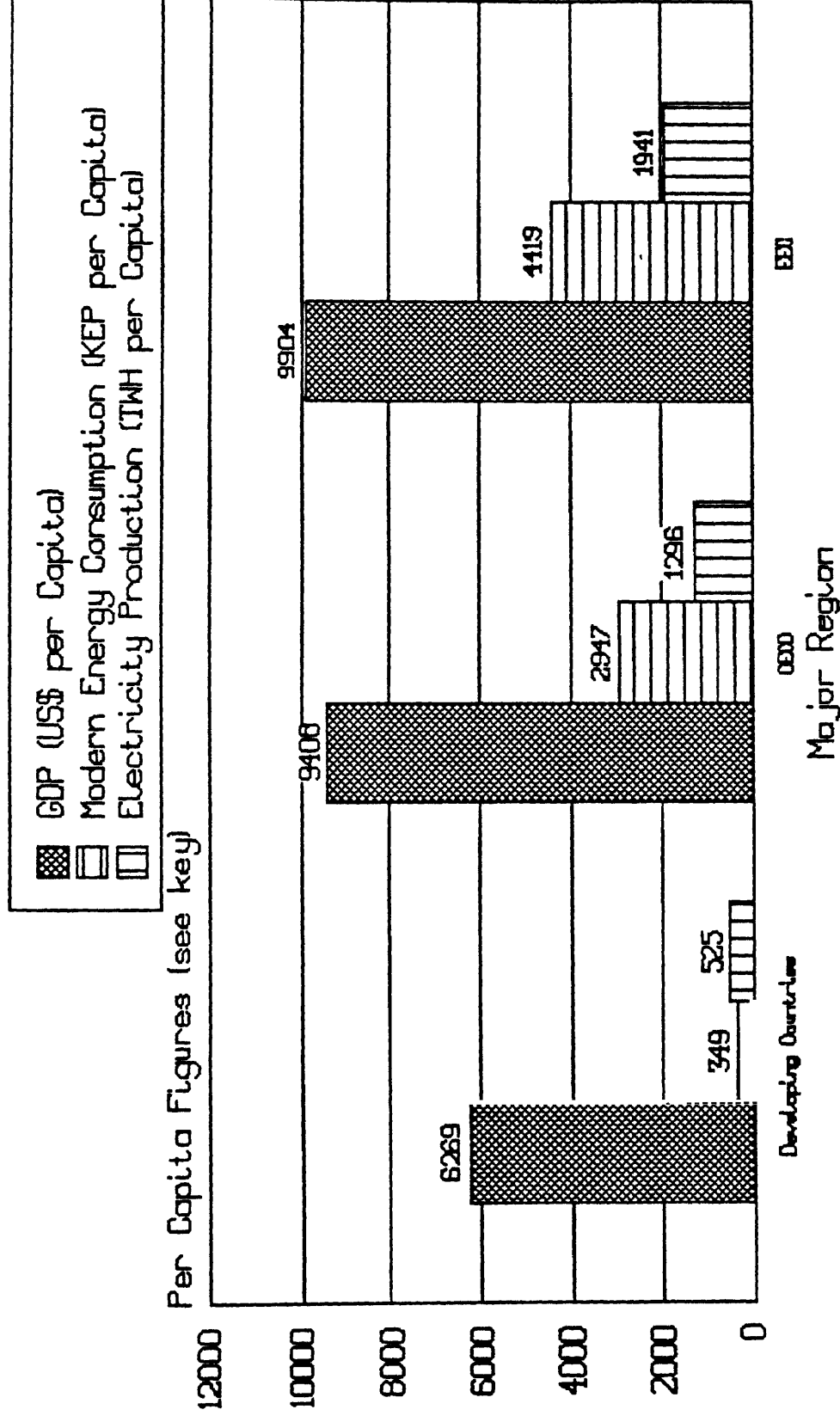
Regional Shares of Total



Key Characteristics of World Regions and Sample Countries



Per Capita Energy and GDP Figures By Major World Region (1987)



Sources: World Bank and IEA

Share of Electricity in total Energy Consumption:					
Sample Countries and EEC.					
ARGENTINA					
	Industry	Household	Transport	Agricultur	Others
1970	9.8	16.6	.4	1.8	3.3
1975	13.9	17.3	.3	2.8	3.4
1980	17.7	19.6	.2	2.9	1.4
1985	19.9	19.2	.3	1.5	4.5
1990	24.1	19.3	.3	2.2	
1995					
2000	27.5	20.5	.4	2.2	
MEXICO					
	Industry	Household	Transport	Agricultur	Others
1970	3.28	1.48	.4	.3	N/A
1975	3.47	1.97	.6	.4	
1980	3.64	2.16	.5	.5	
1985	4.16	2.41	.6	.5	
1990					
1995					
2000					
BRAZIL					
	Industry	Household	Transport	Agricultur	Others
1970	10.2	3.8	.4	.6	60.8
1975	12.5	5.9	.2	1.4	64.1
1980	15.8	10.7	.3	3.3	71.1
1985	20.6	16.7	.4	7.5	80.3
1990	22.1	25.7	.3	10.1	82.6
1995					
2000	24.1	49.6	.3	12.6	89.6
2010	25.9	71.1	.3	13.8	94.2
THAILAND					
	Industry	Household	Transport	Agricultur	Others
1970					
1975	15.8	2.5		0	18.1

1980	12.7	5.1		.2	53.2
1985	14.4	8.5		.6	70.5
1990					
2000					
PIA					
	Industry	Household	Transport	Agricultur	Others
1970					
1975	10.8	13.2	1.1	66.8	4.3
1980	11.1	16.2	1.1	78.4	4.4
1985	13.1	20.2	1.3	82.7	4.3
1990					
1995					
2000					
EC COUNTRIES					
	Industry	Household	Transport	Agricultur	Others
1970	12.4	9.8	1.6	10.1	20.1
1975	14.9	14.4	1.5	10.2	16.8
1980	16.8	19.2	1.4	11.6	17.2
1985	19.2	20.7	1.4	12.8	22.7

[illegible]

Structure of Generating Capacity (total Gwh and sector percentages)									
ARGENTINA									
year	total (gw)	Hydro	Thermal	-----	-----	-----	-----	Gas	Nuclear
					steam	diesel			
1970	48.62	12.00	80.00	64.00	16.00	8.00			.00
1975	72.18	21.00	59.00	49.00	10.00	15.00			5.00
1980	100.86	36.00	46.00	38.00	8.00	15.00			4.00
1985	139.94	43.00	36.00	31.00	5.00	14.00			7.00
1990	156.35	42.00	39.00	34.00	5.00	13.00			7.00
1995									
2000	242.85	59.00	22.00	19.00	3.00	9.00			10.00

Structure of Generating Capacity (total Gwh and sector percentages)									
CHINA									
Year	total (gw)	Hydro	Thermal	coal	fuel	gas	diesel	Nuclear	
1970	23.77	26.20	73.80						
1975	43.41	30.90	69.10	48.30	20.10	.50	.20		
1980	65.87	30.80	69.20	50.70	17.70	.50	.20		
1985	87.05	30.40	69.60	57.10	11.80	.60	.20		
1990	131.67	29.60	70.10					.20	
1995	177.76	30.60	68.20					1.20	
2000	240.00	31.10	66.40					2.50	

Structure of Generating Capacity (total Gwh and sector percentages)					
INDIA					
year	total (gwh)	Hydro	Thermal	Others	
1970	14.71	43.40	53.70	2.90	
1975	20.12	42.10	54.70	3.20	
1980	30.12	39.00	56.70	2.80	
1985	46.77	33.10	61.60	2.80	
1990	70.42			2.50	
1995					
2000	171.58				

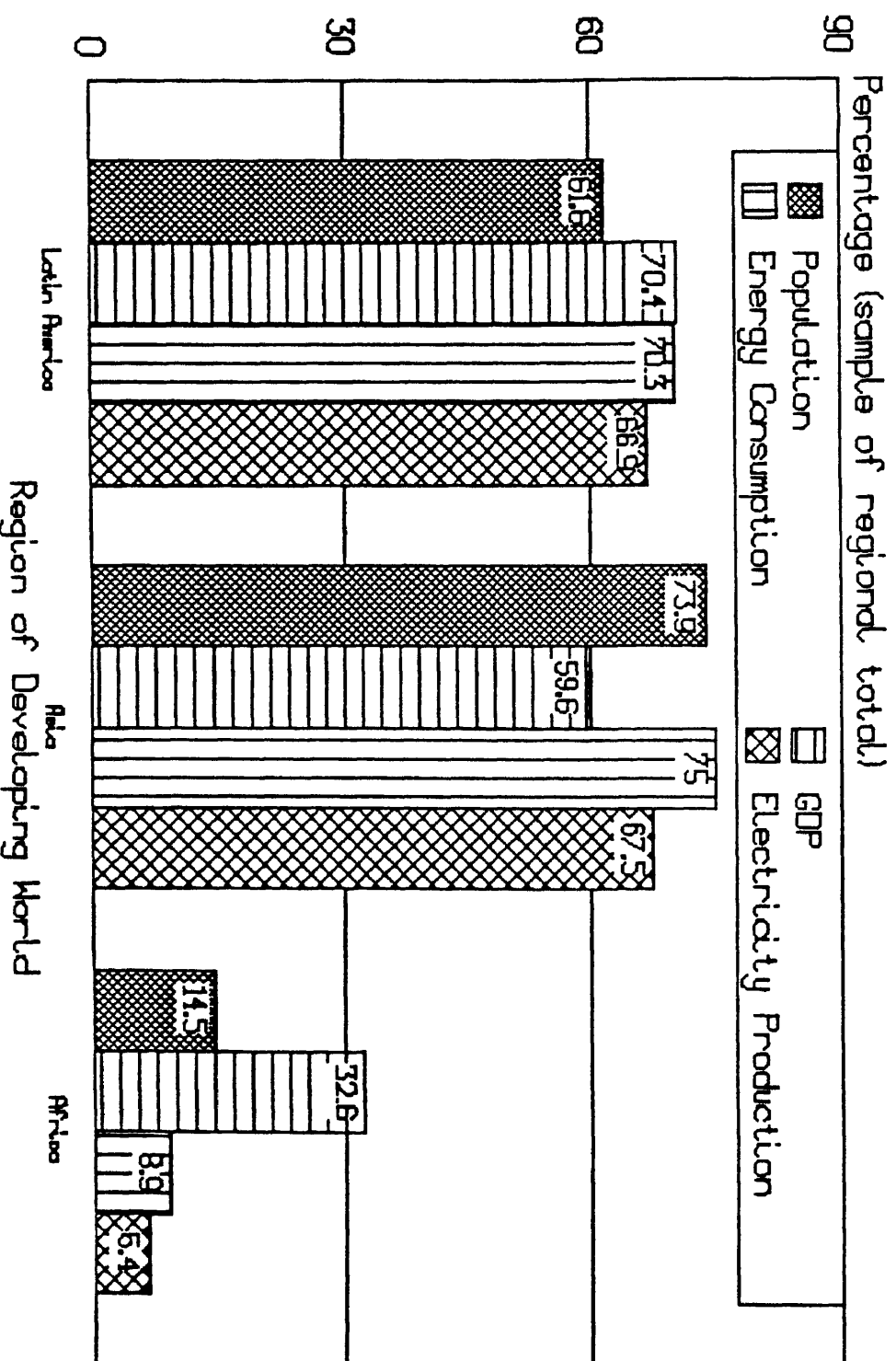
Structure of Generating Capacity (total Gwh and sector percentages)									
THAILAND									
Year	total (gw)	Hydro	Thermal	steam	gas	diesel			
1970	13.36	33.80	66.20	42.50	11.20	12.50			
1975	27.55	33.00	67.00	53.70	6.00	7.30			
1980	38.49	33.00	67.00	52.40	7.40	7.20			
1985	73.95	37.10	72.90	54.60	13.30	5.00			
1990	75.69	29.70	70.30	56.60	13.70				
1995									
2000	178.09	19.90	80.10	65.10	15.00				

Structure of Generating Capacity (total Gwh and sector percentages)								
BRAZIL								
year	total (gw)	hydro	thermal	steam	coal	fuel	nuc1	others
								diesel
1970	10.29	83.90	16.10	12.40	2.40	9.90		.10
1975	18.48	86.40	13.60	10.70	2.70	8.00		3.70
1980	30.57	88.60	11.40	8.60	2.50	6.10		2.90
1985	39.78	89.00	11.00	8.50	1.80	5.00	1.70	2.80
1990	58.50	91.30	8.70	8.70	2.20		1.00	2.50
1995								
2000	103.00	88.60	9.40	9.40	2.90		3.00	3.50

Structure of Generating Capacity (total Gwh and sector percentages)										
MEXICO										
year	total (gW)	Hydro	Thermal	steam	coal	fuel	gas	Gas	Diesel	Others
1970	6.07	53.19	46.79	38.77		38.77			8.02	
1975	9.83	41.13	47.62	38.87		38.87	6.20	10.60	2.55	.76
1980	15.93	40.97	49.85	45.23		45.23	3.69	8.13	.93	1.02
1985	21.45	31.39	57.94	50.45	4.32	46.13	6.96	8.59	.53	2.04
1990	26.66	29.33	58.54	51.76	4.50	47.26	6.18	6.75	.60	5.36
1995										
2000	46.85	23.25	61.42	59.01	22.30	36.71	2.07	5.46	.34	6.68

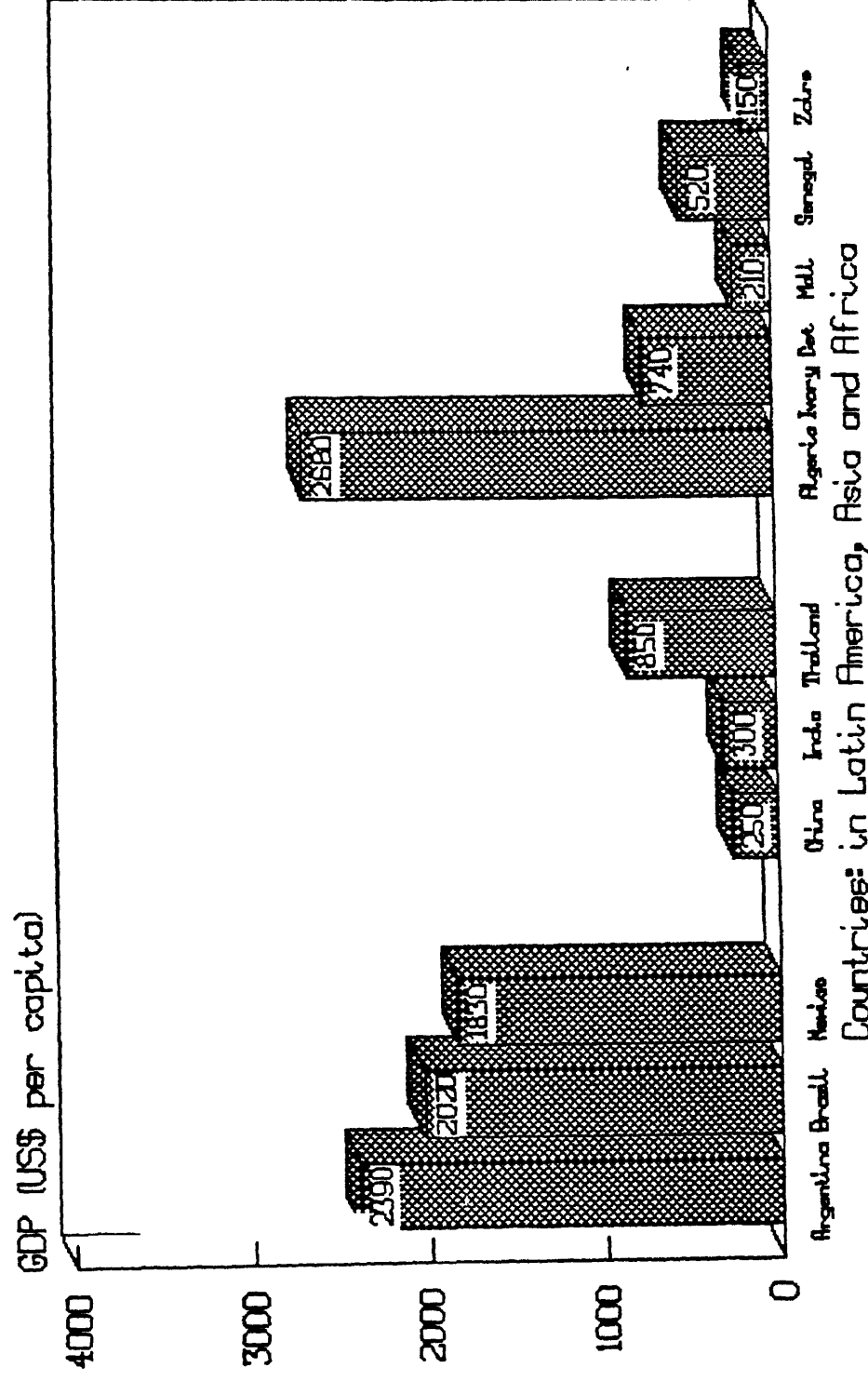
Sample's Percentage Share in their Regional Energy Characteristics

Population, GDP, Energy Consumption and Electricity Production (1987)



Source: World Bank and IEA

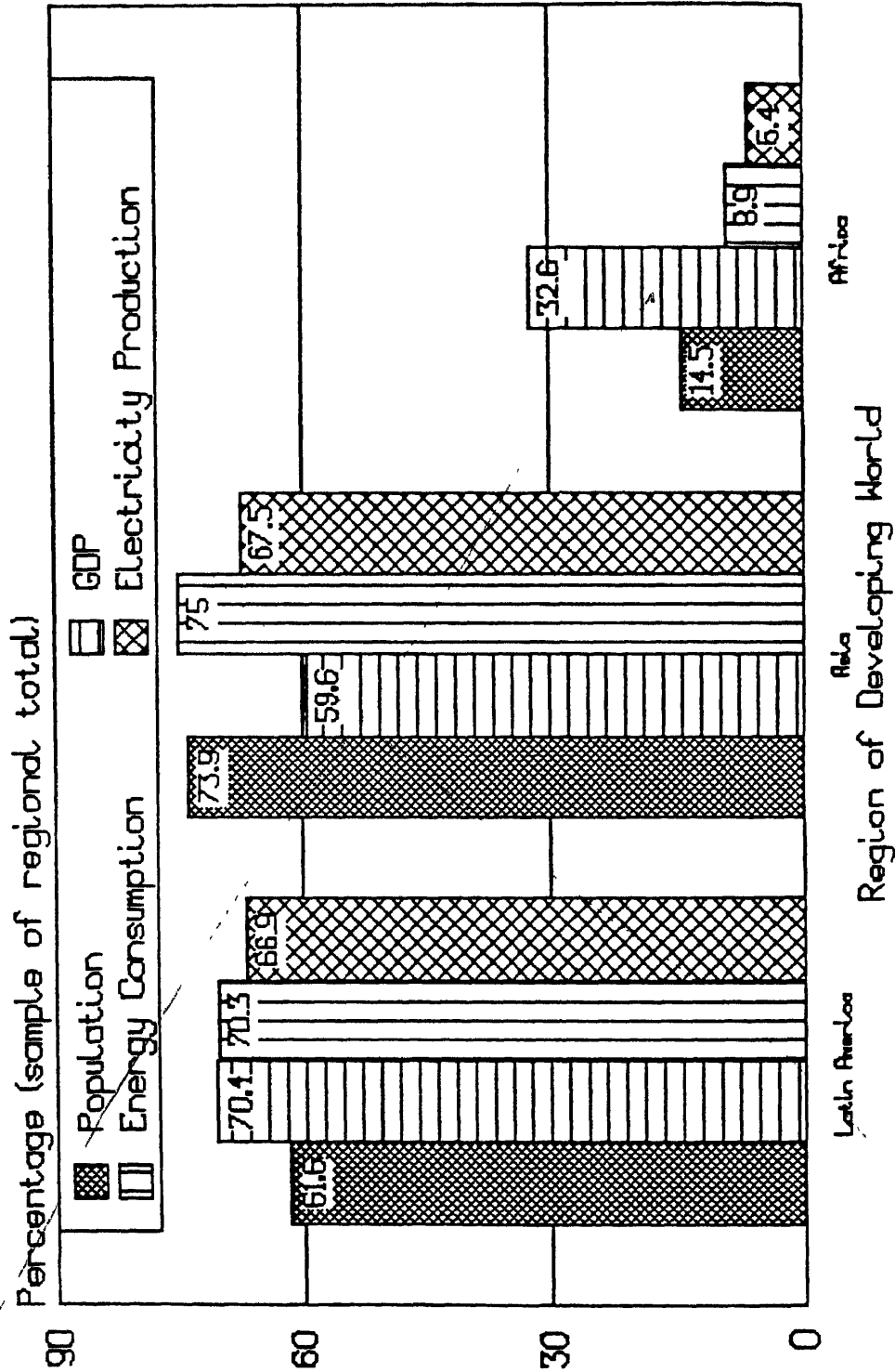
GDP per Capita in Sample Countries: Grouped by Region (1987)



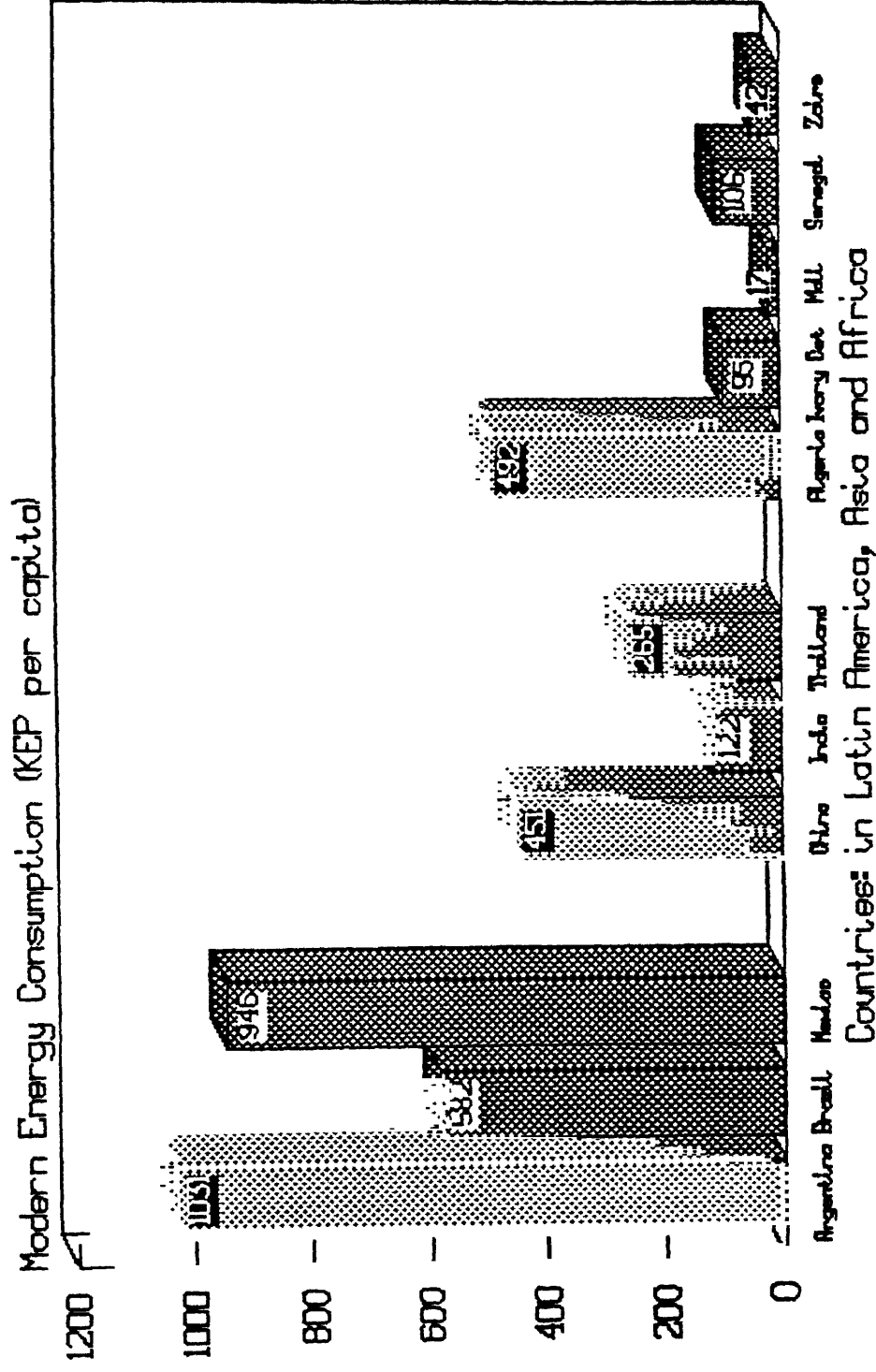
Source: World Bank and IFA

Sample's Percentage Share in their Regional Energy Characteristics

Population, GDP, Energy Consumption and Electricity Production (1987)

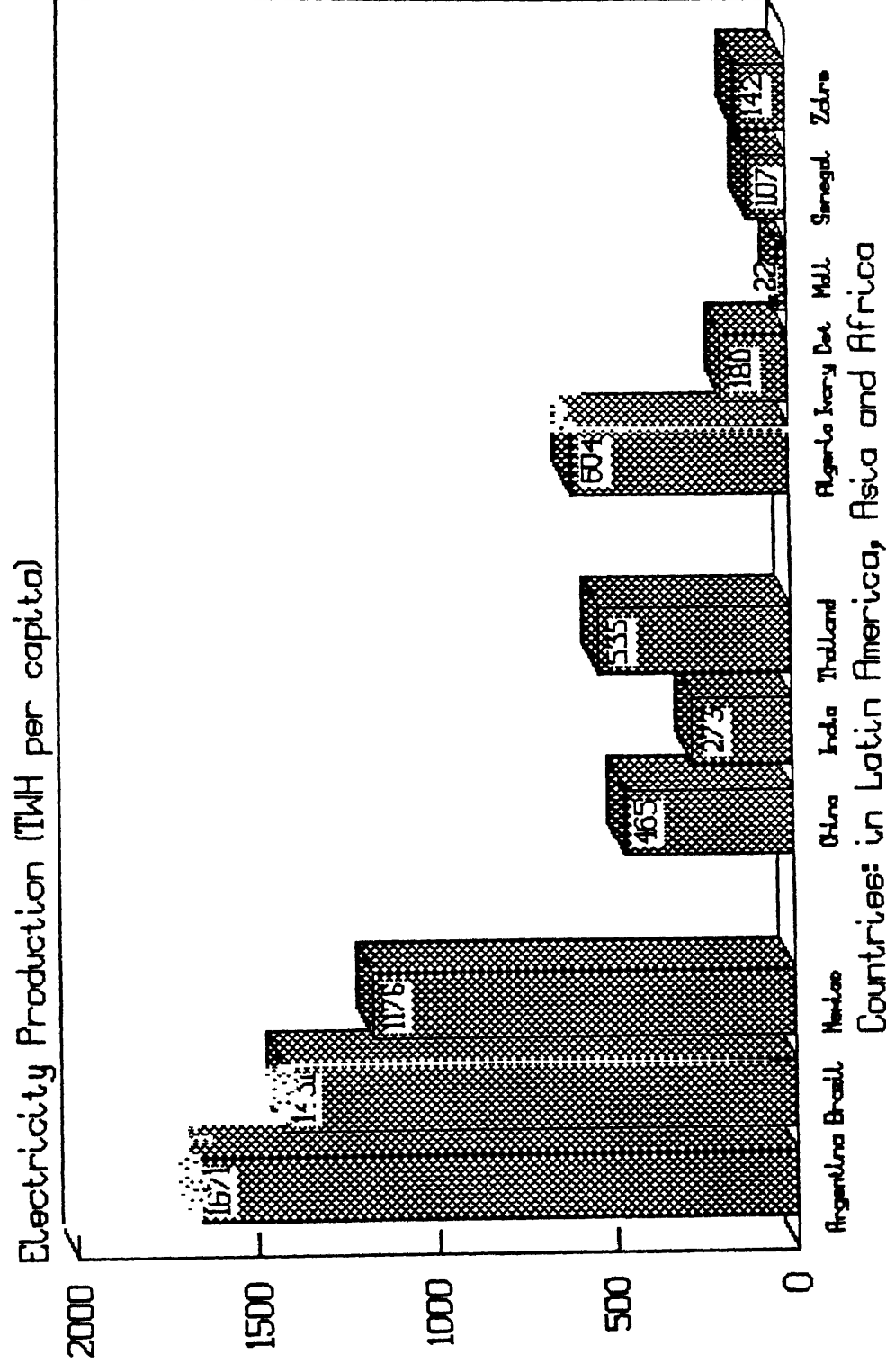


Energy Consumption in Sample Countries: Grouped by Region (1987)



Source: World Bank and IEA

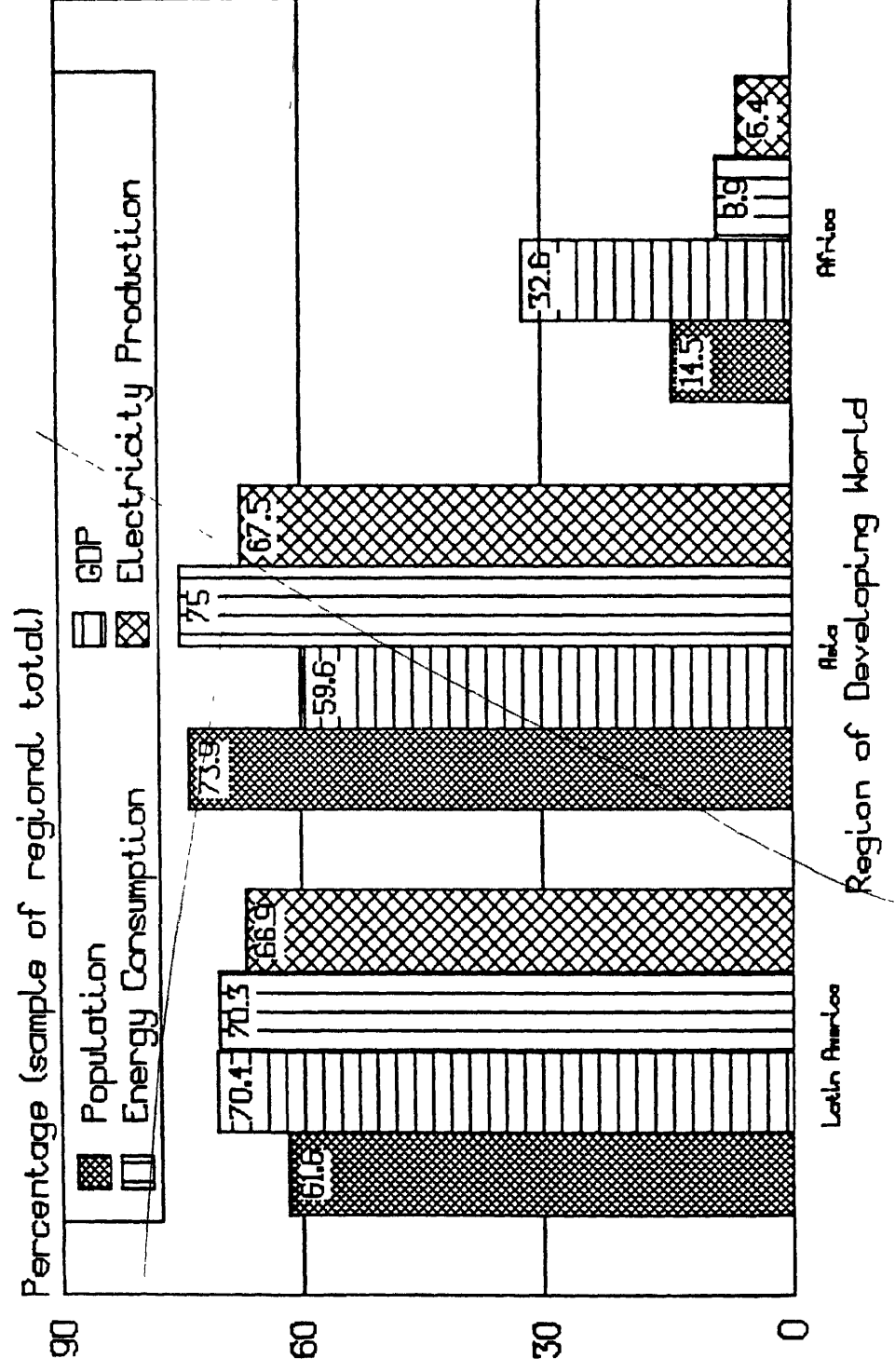
Electricity Production in Sample Countries: Grouped by Region (1987)



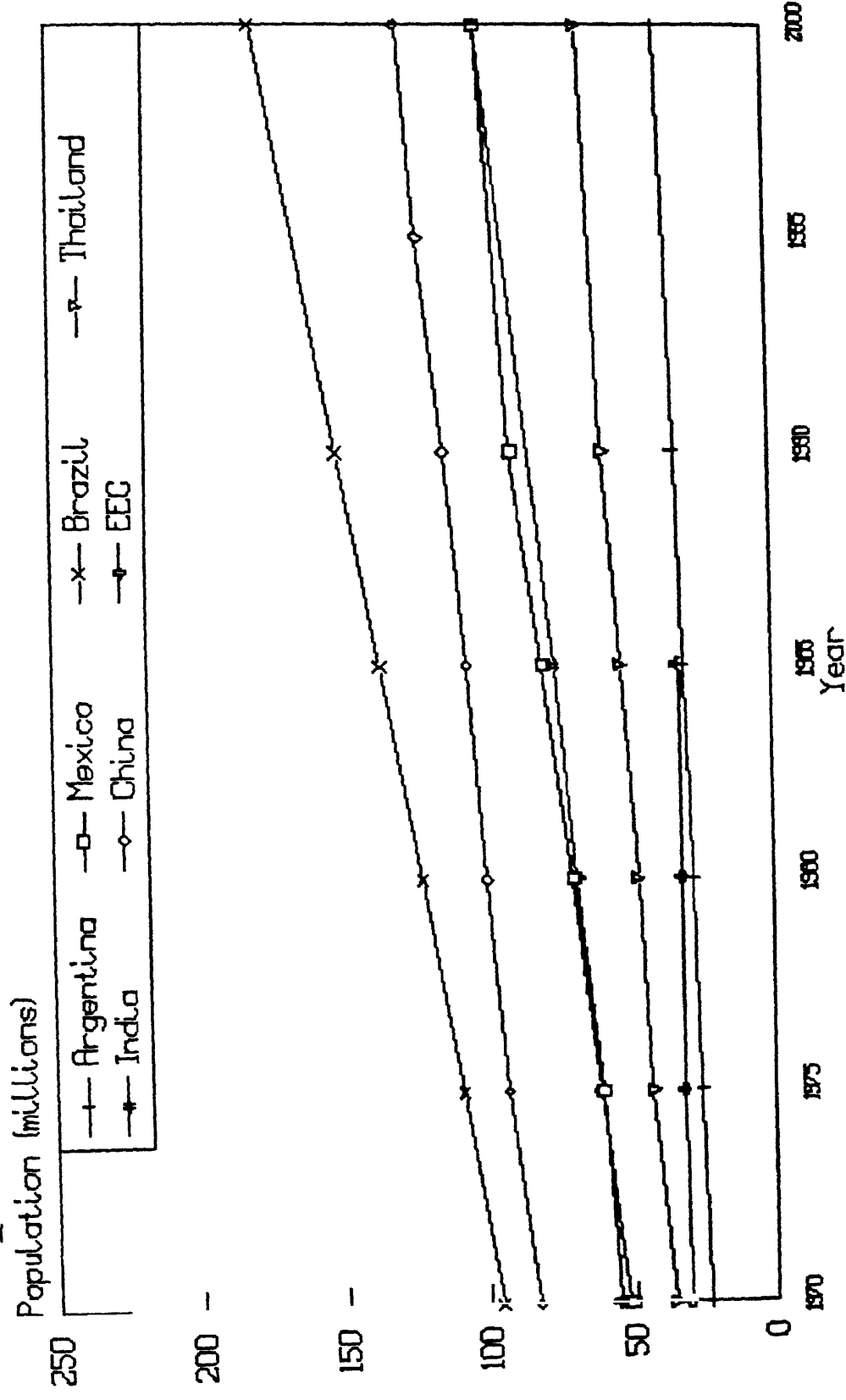
Source: World Bank and IEA

Sample's Percentage Share in their Regional Energy Characteristics

Population, GDP, Energy Consumption and Electricity Production (1987)

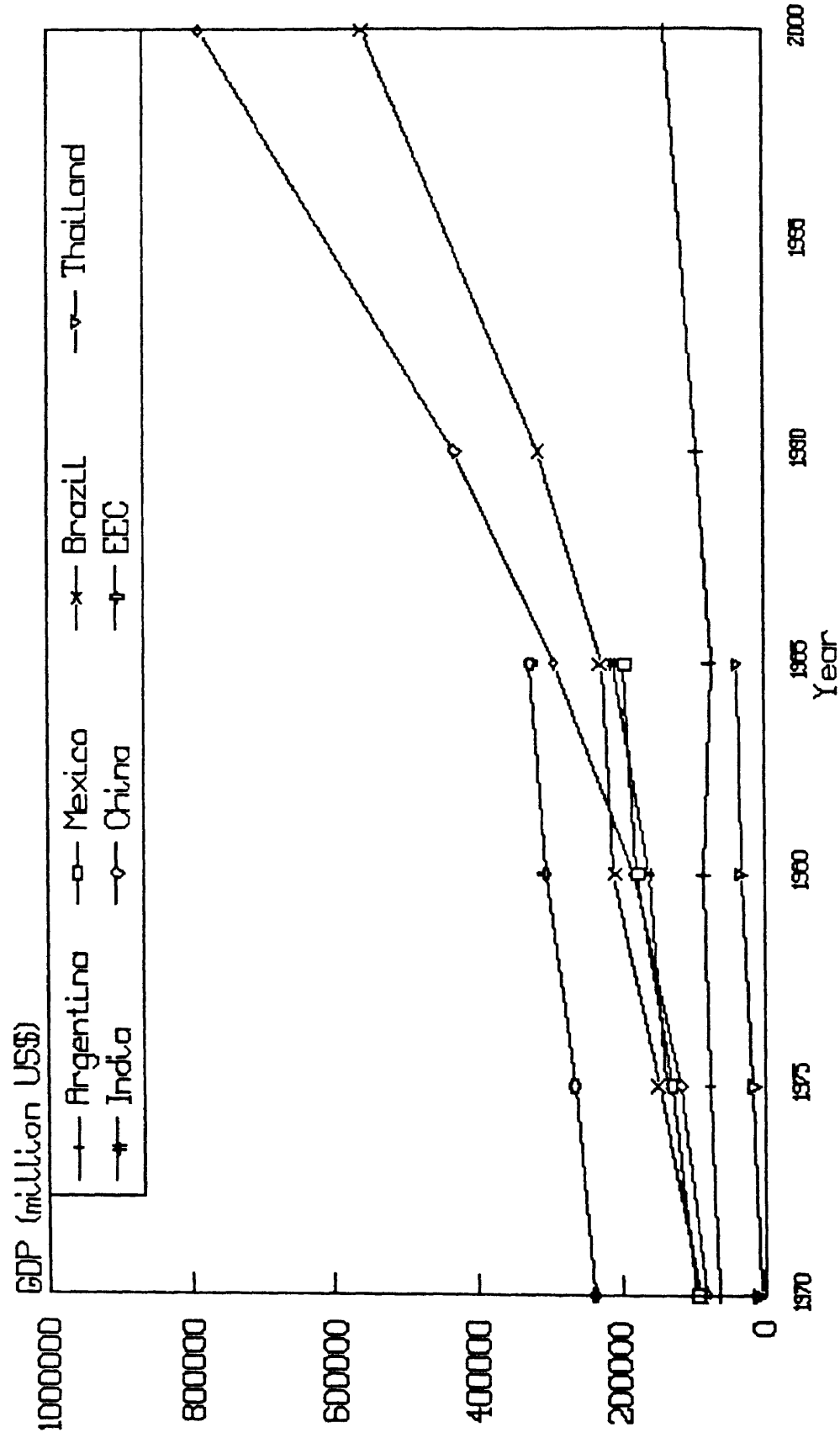


Sample Country and EEC Trends: Population



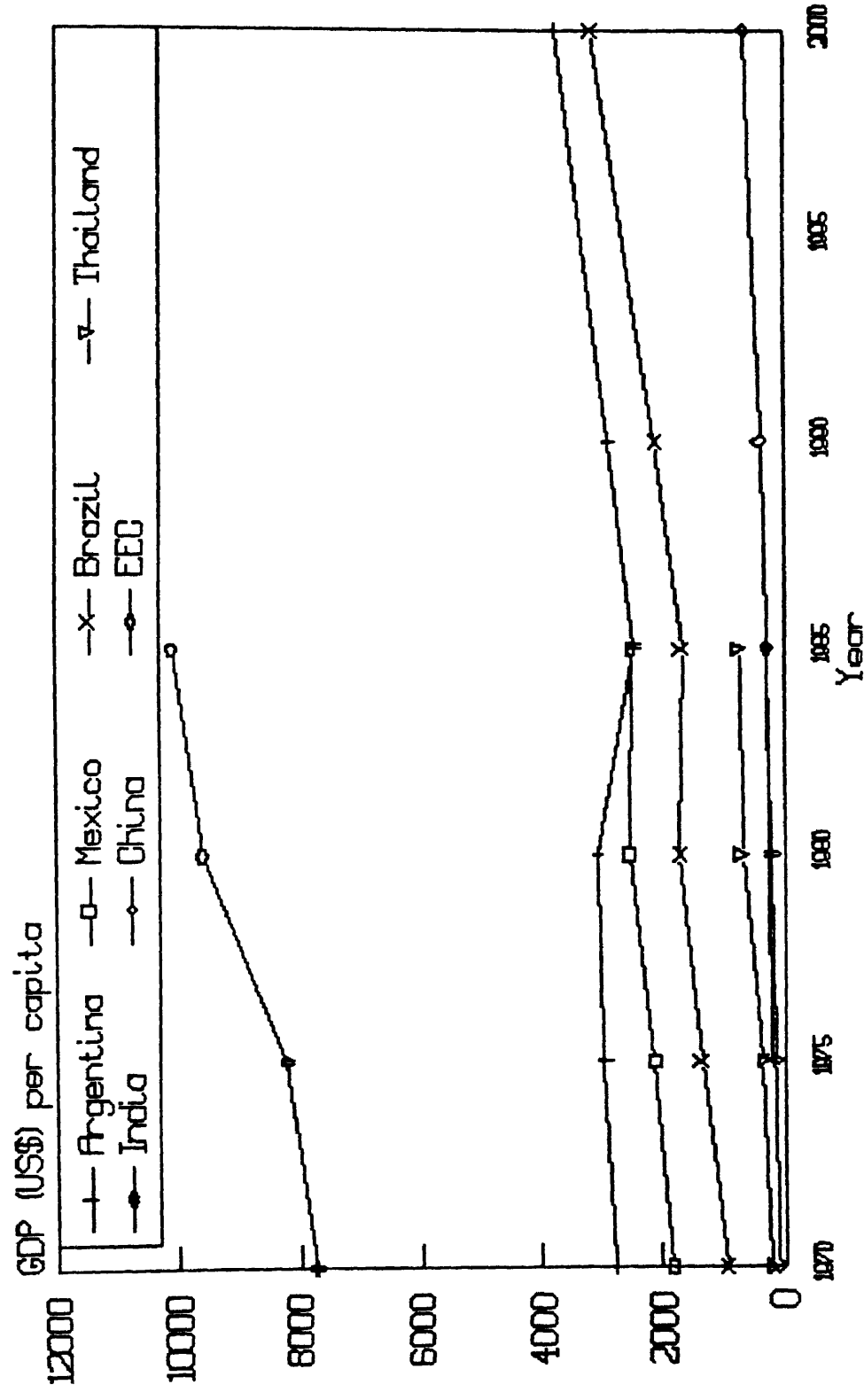
Notes: China, India and EEC figures divided by 10 for comparability
Source: Various

Sample Country and EEC Trends: GDP



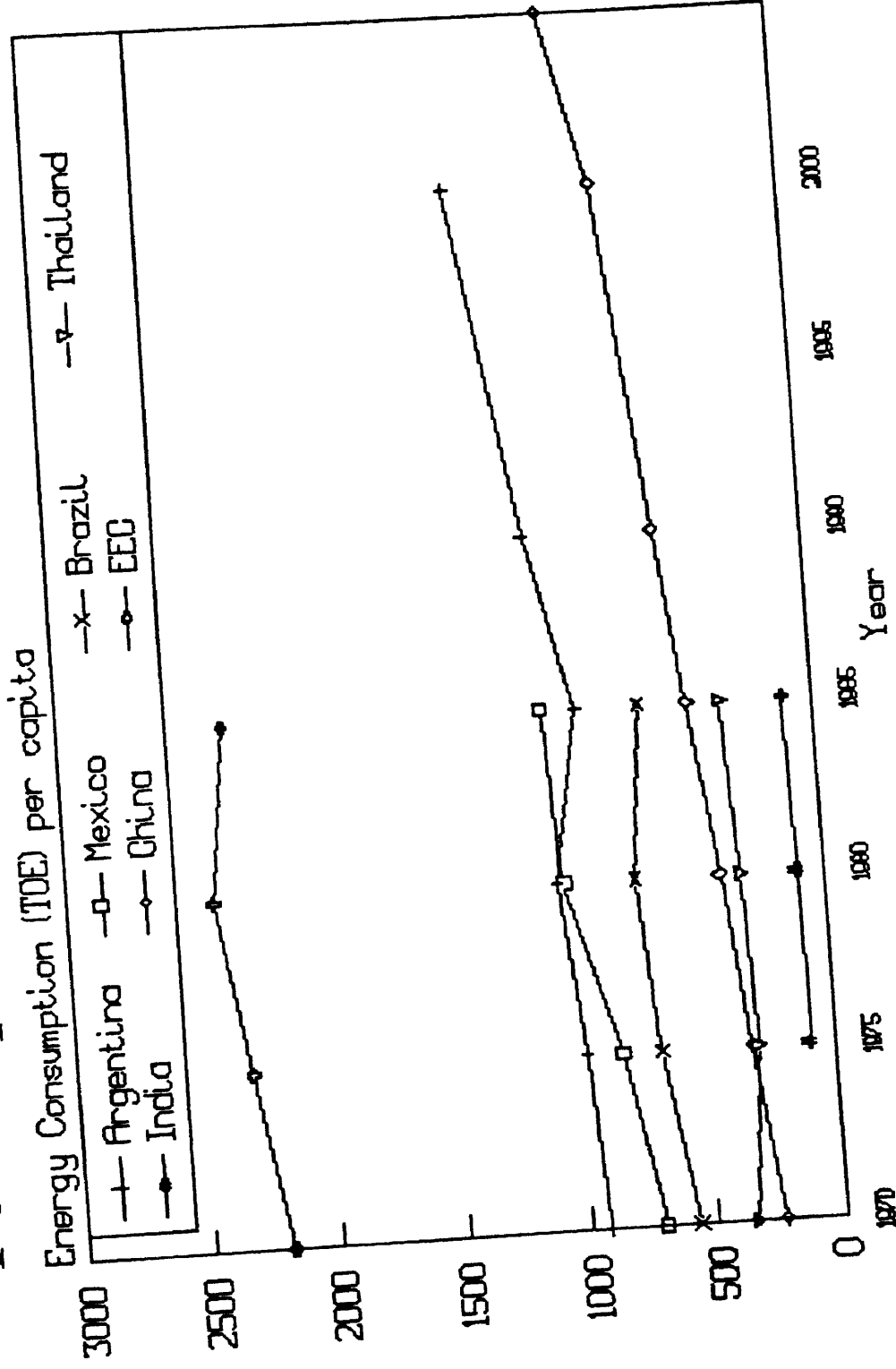
Notes: EEC figures divided by 10 for comparability
Source: Various

Sample Country and EEC Trends: Per Capita GDP



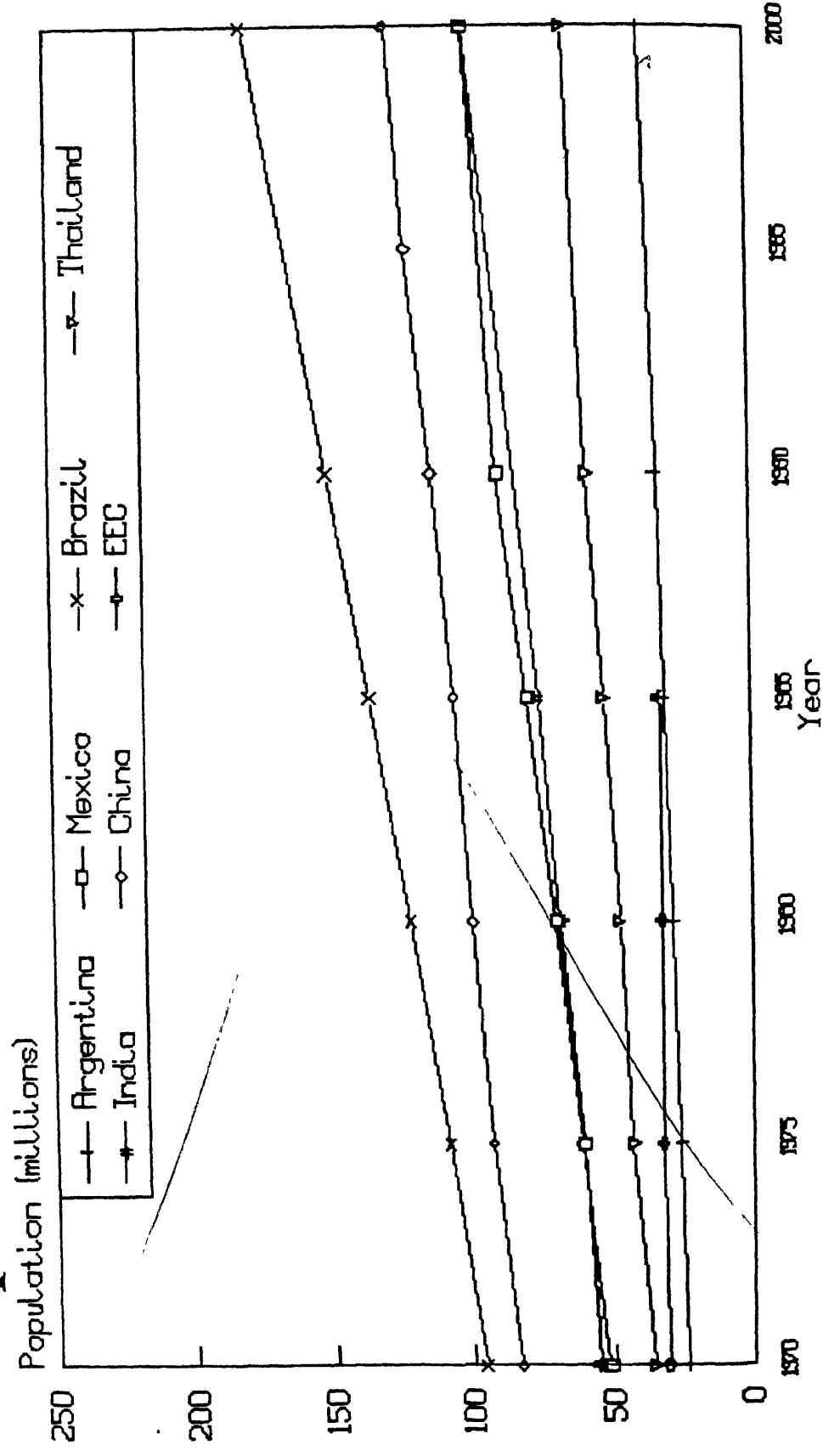
Source: Various

Sample Country and EEC Trends: Per Capita Energy Consumption



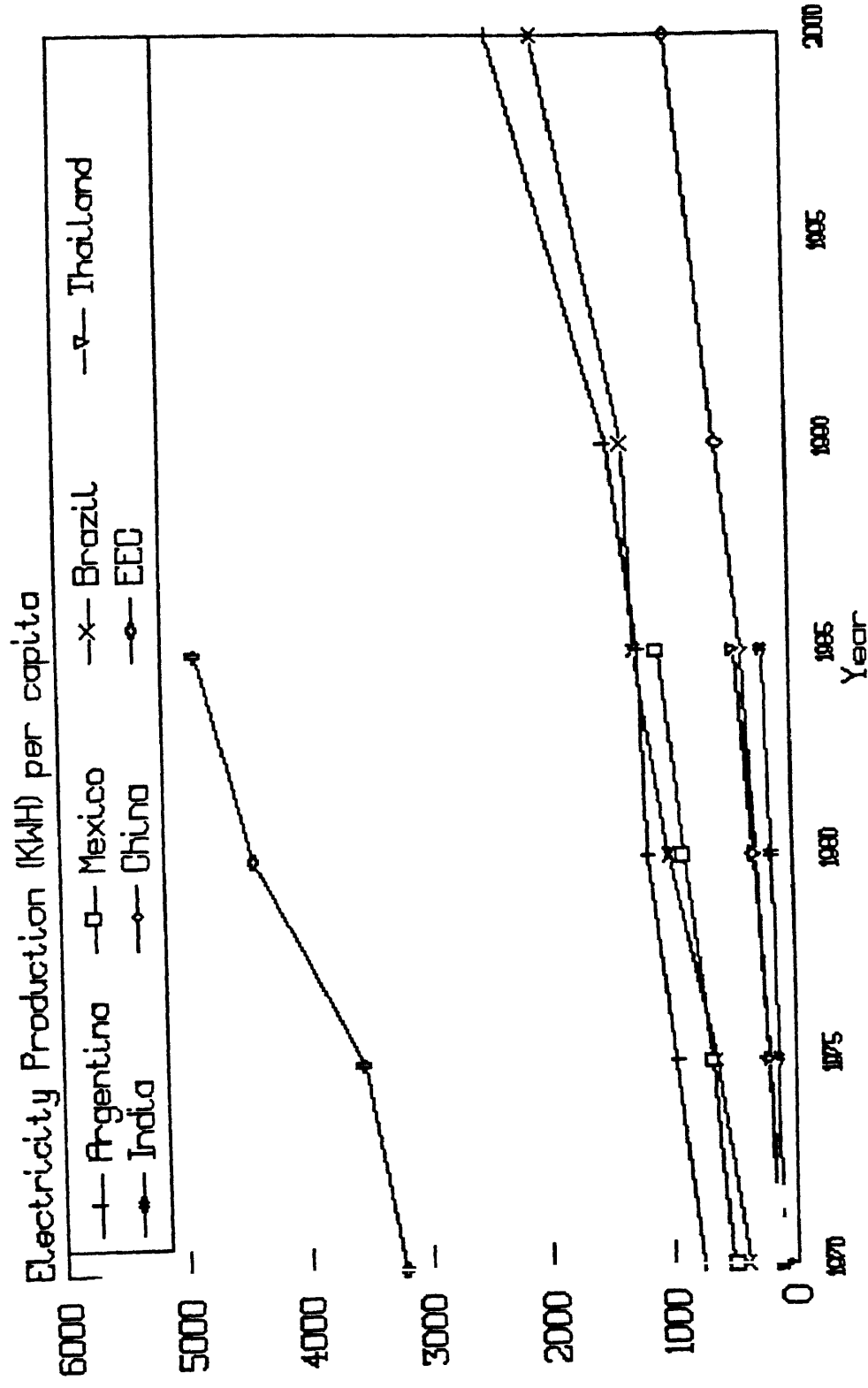
Source: Various

Sample Country and EEC Trends: Population



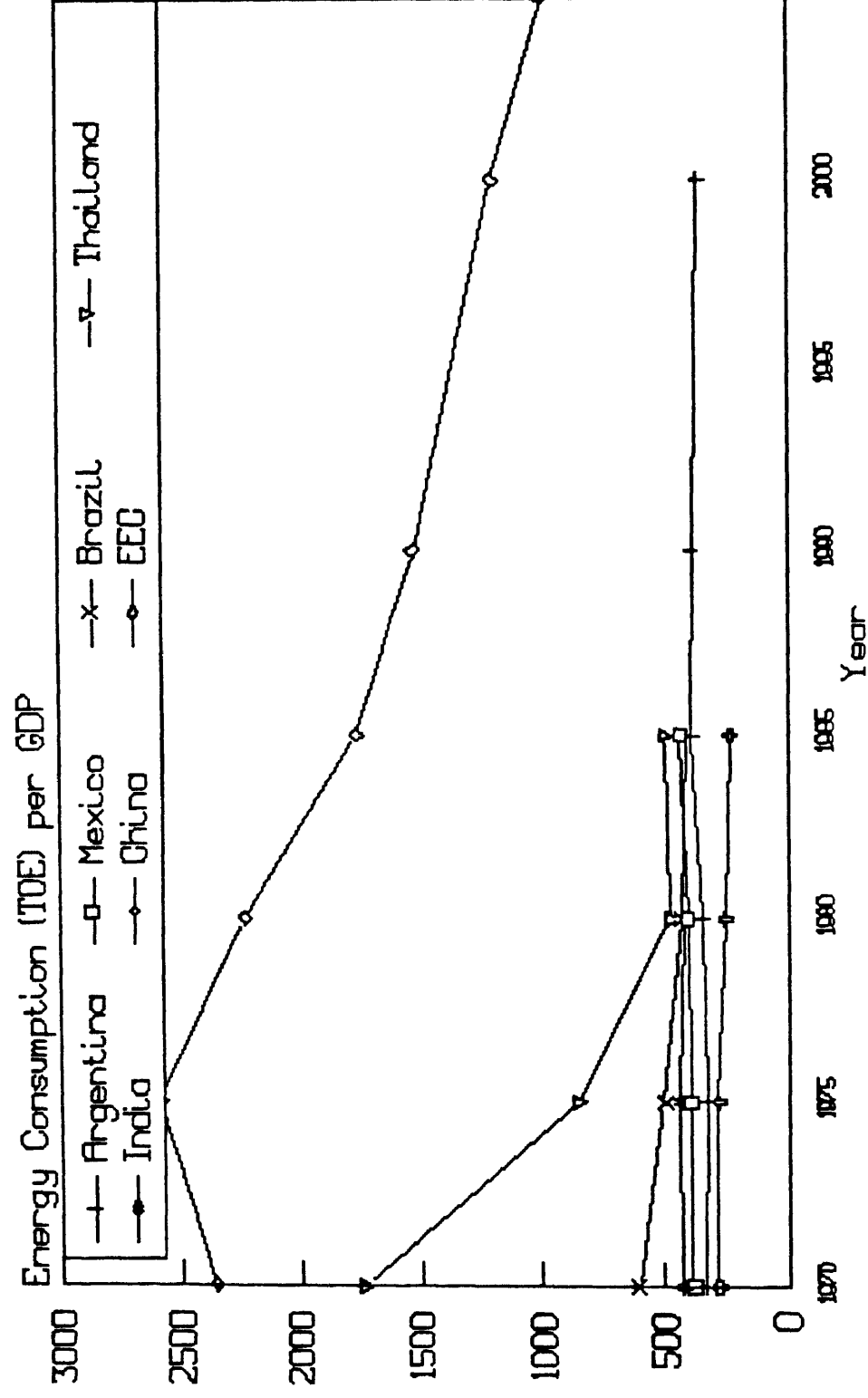
Notes: China, India and EEC figures divided by 10 for comparability
Source: Various

Sample Country and EEC Trends: Per Capita Electricity Production



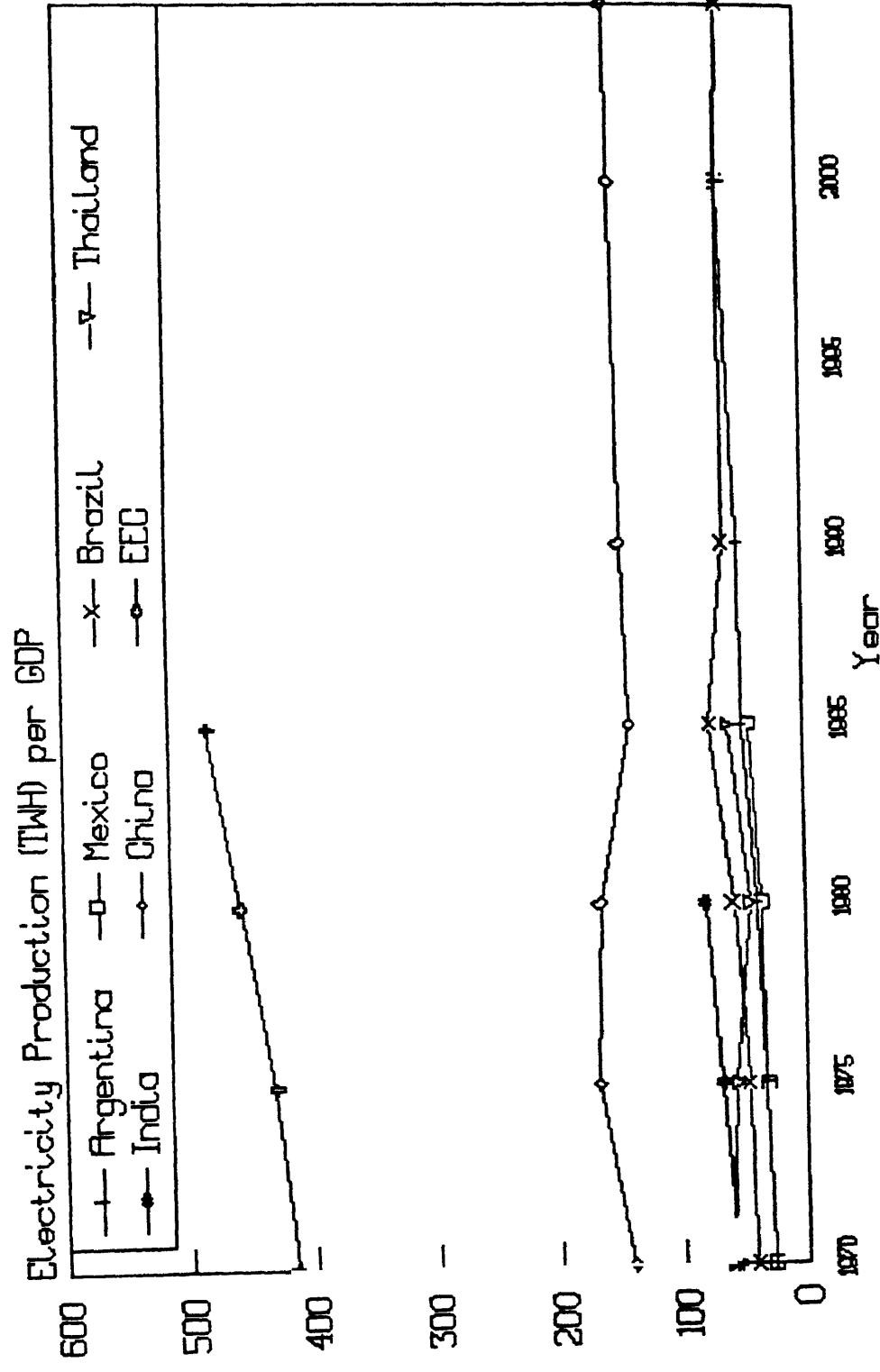
Source: Various

Sample Country and EEC Trends: Energy Consumption per GDP



Source: Yarruque

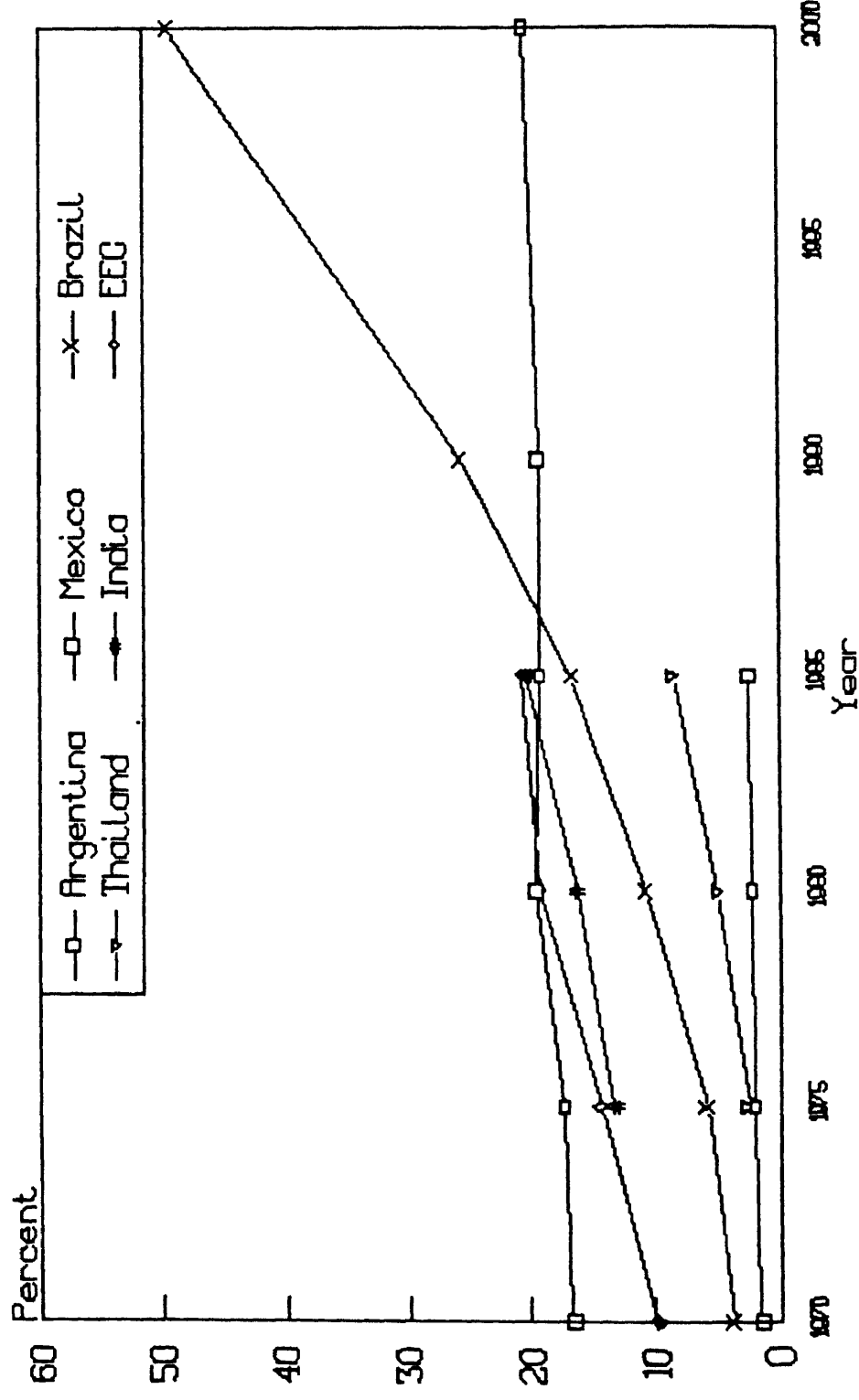
Sample Country and EEC Trends: Electricity Production per GDP



Source: Varique

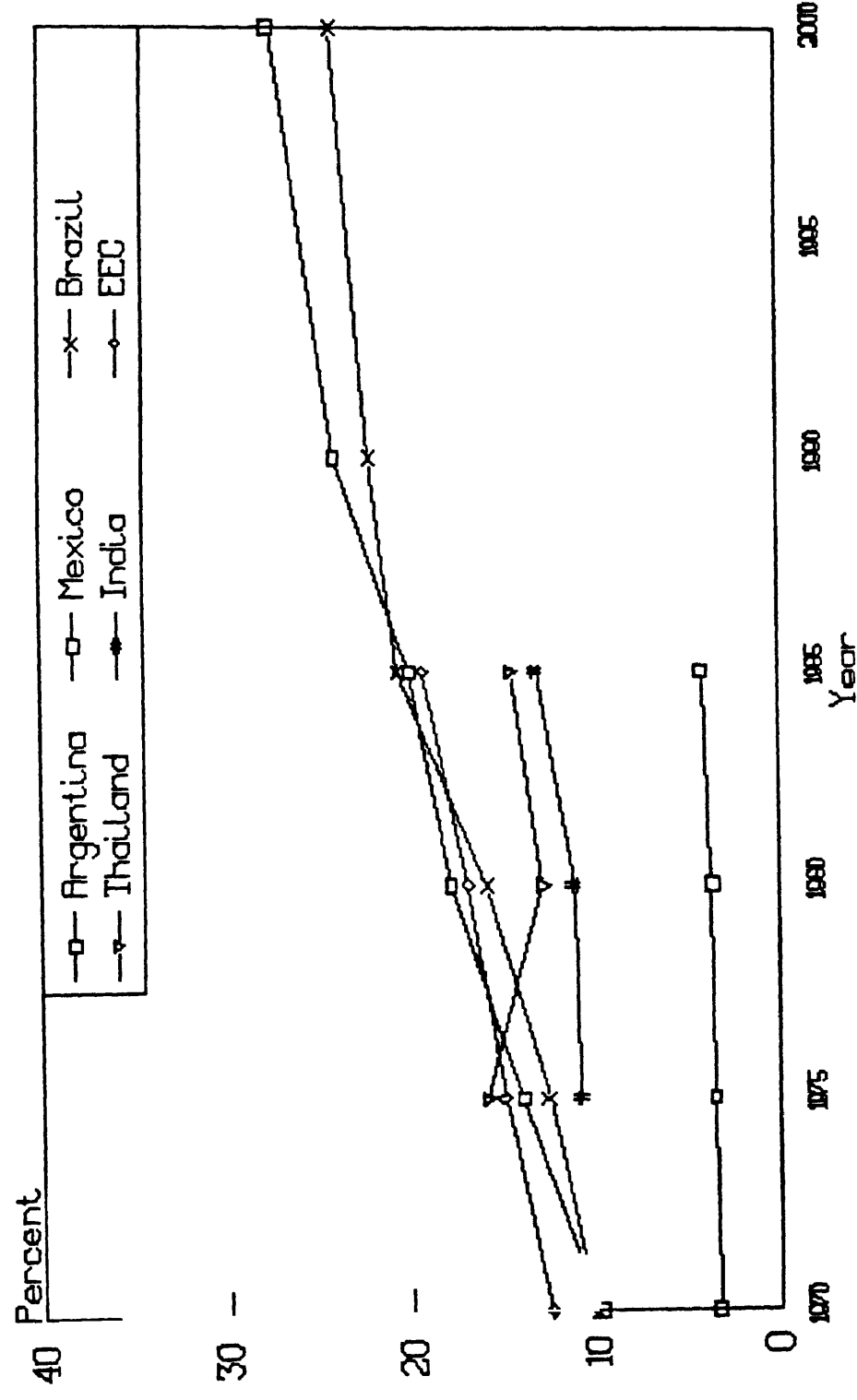
Share of Electricity in Total Energy Consumption:

HOUSEHOLD SECTOR



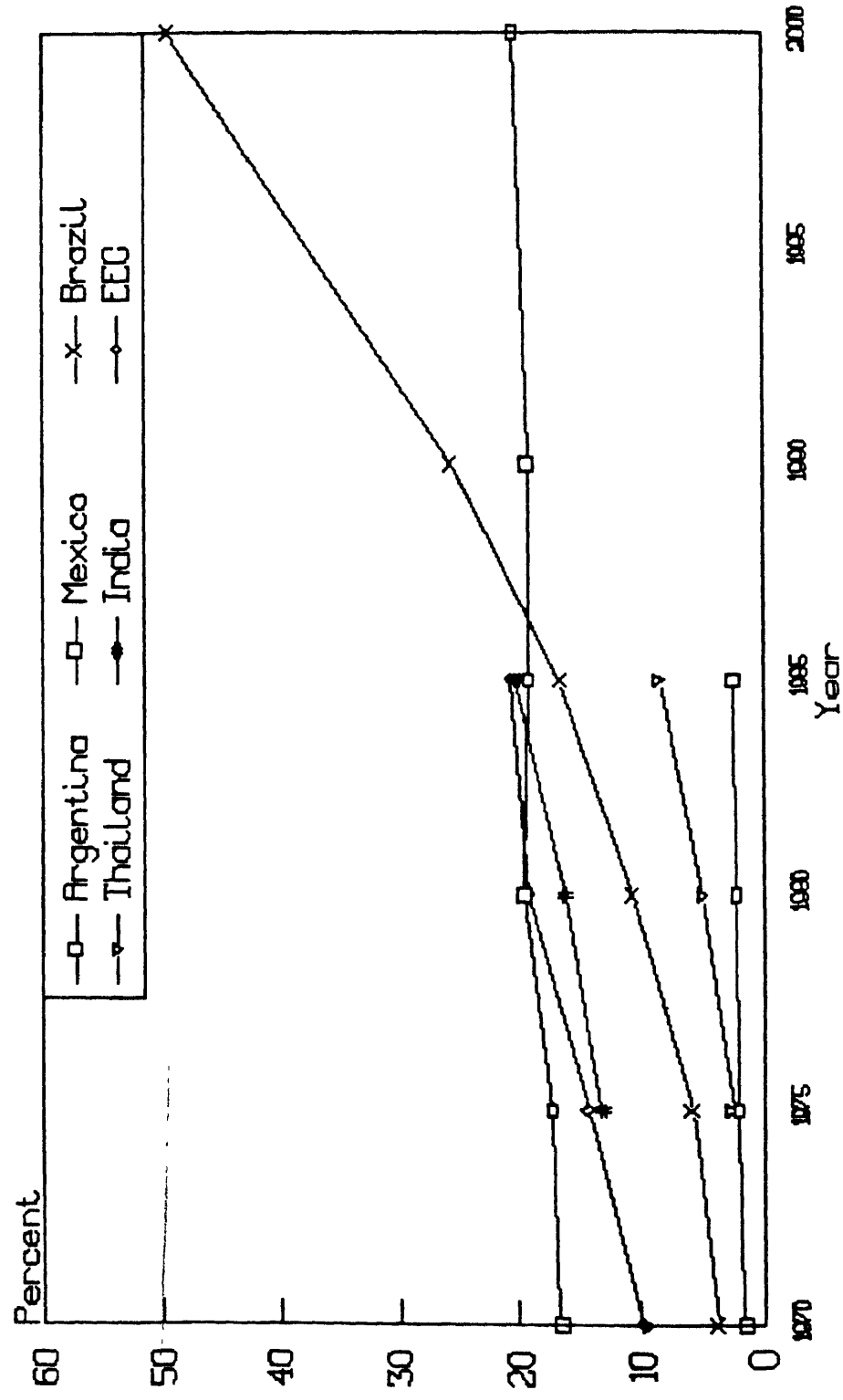
Share of Electricity in Total Energy Consumption:

INDUSTRY SECTOR



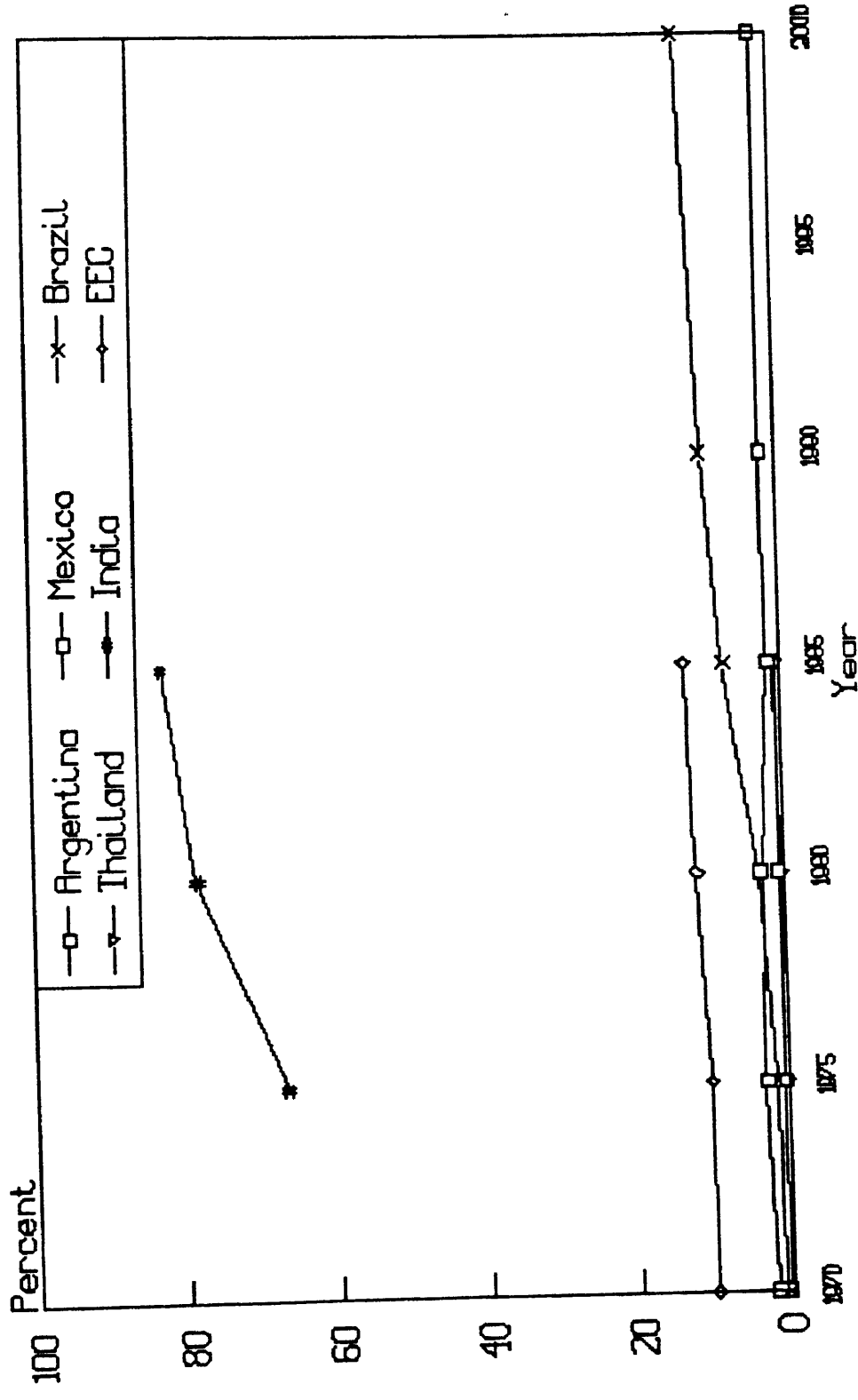
Share of Electricity in Total Energy Consumption:

HOUSEHOLD SECTOR



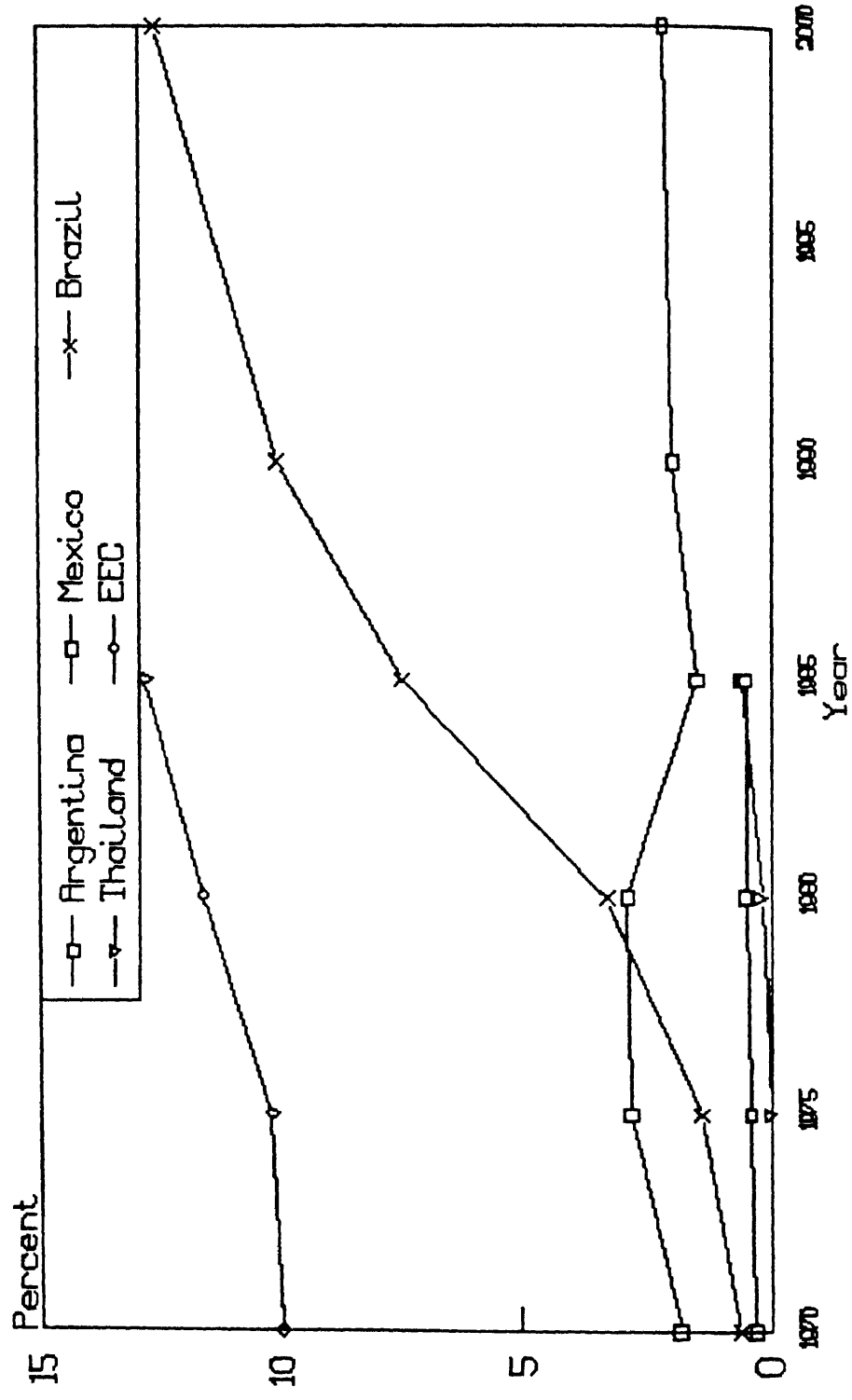
Share of Electricity in Total Energy Consumption:

AGRICULTURE SECTOR



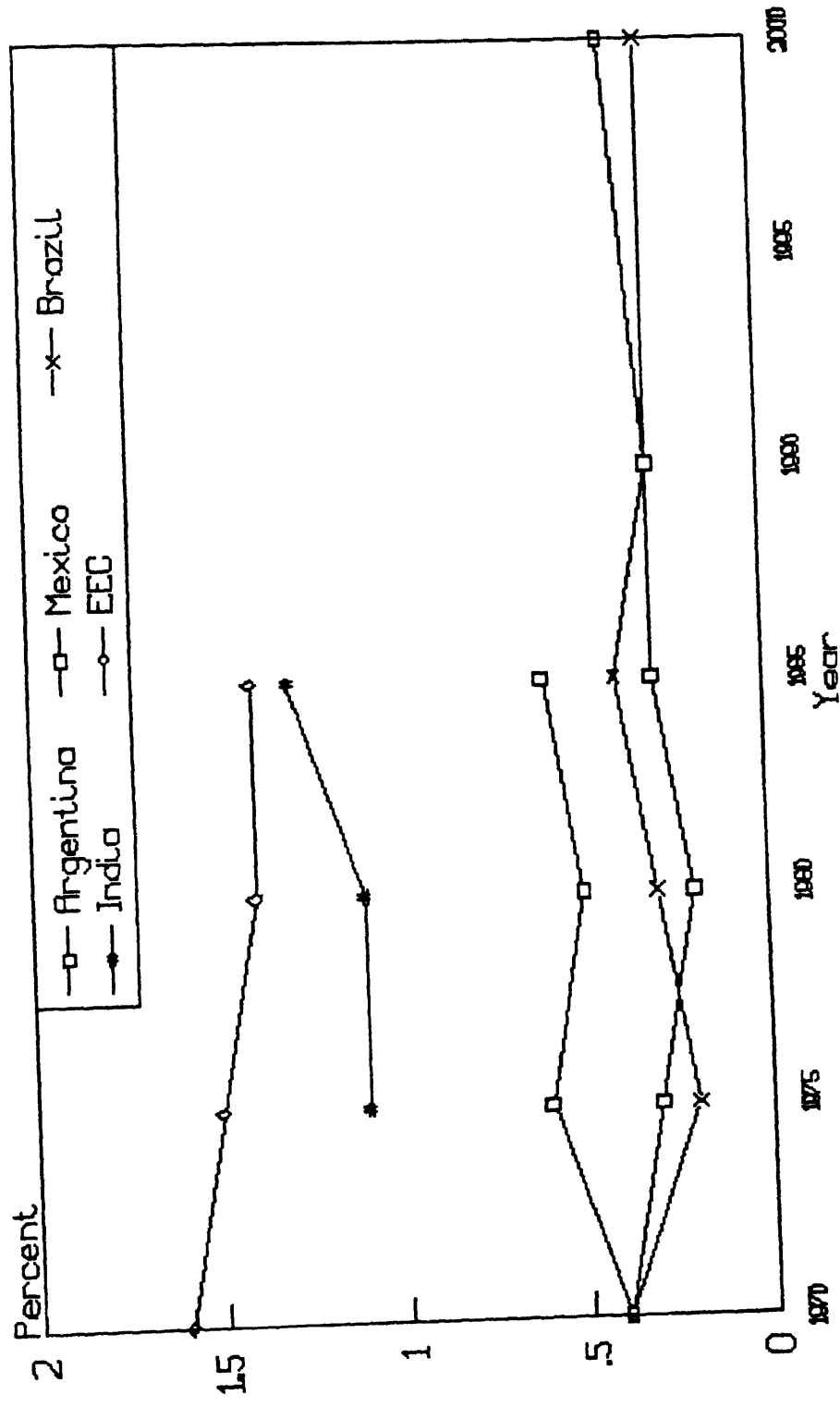
Share of Electricity in Total Energy Consumption:

AGRICULTURE SECTOR
(version 2: without India)



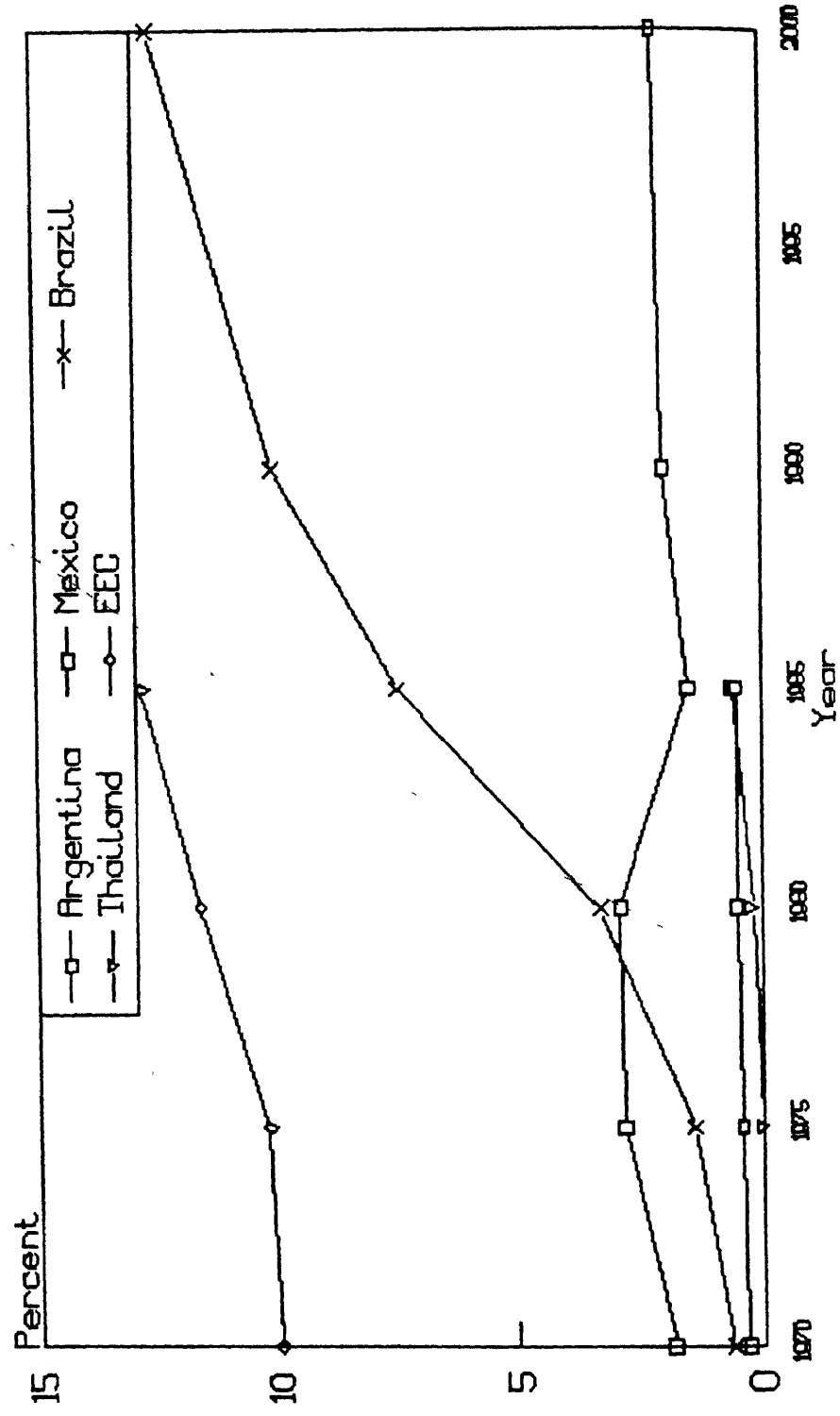
Share of Electricity in Total Energy Consumption:

TRANSPORT SECTOR



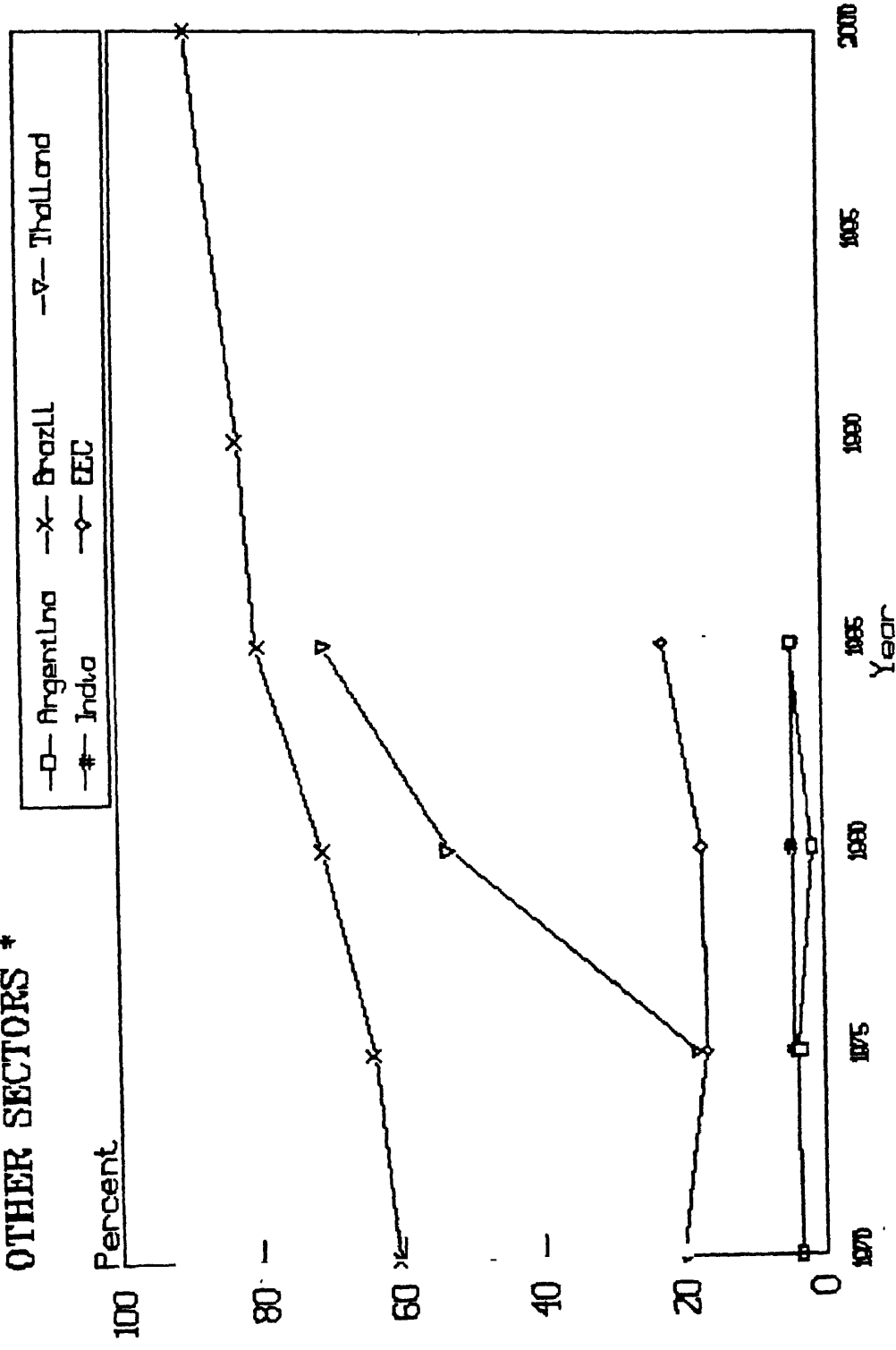
Share of Electricity in Total Energy Consumption:

AGRICULTURE SECTOR
(version 2: without India)



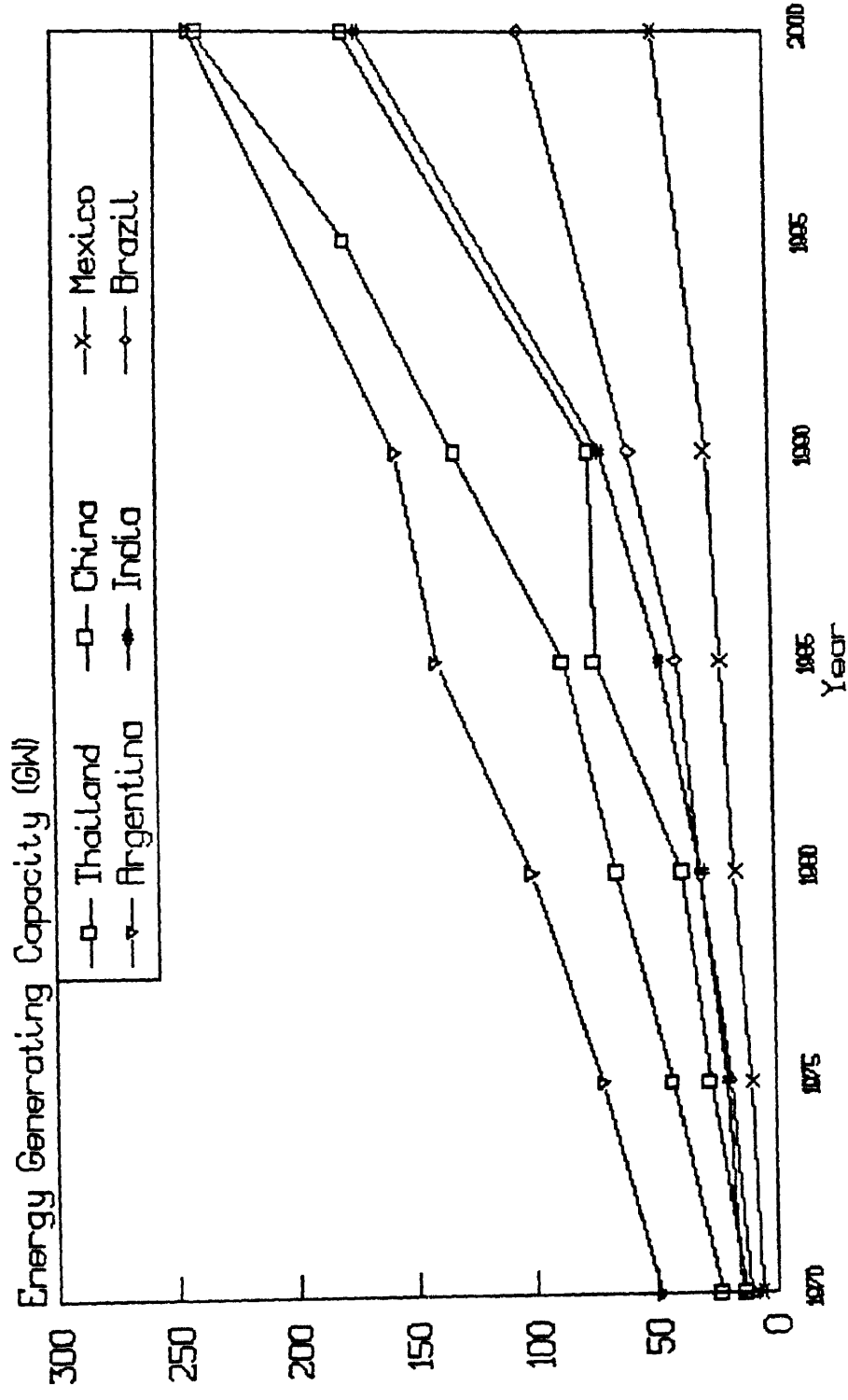
Share of Electricity in Total Energy Consumption:

OTHER SECTORS *

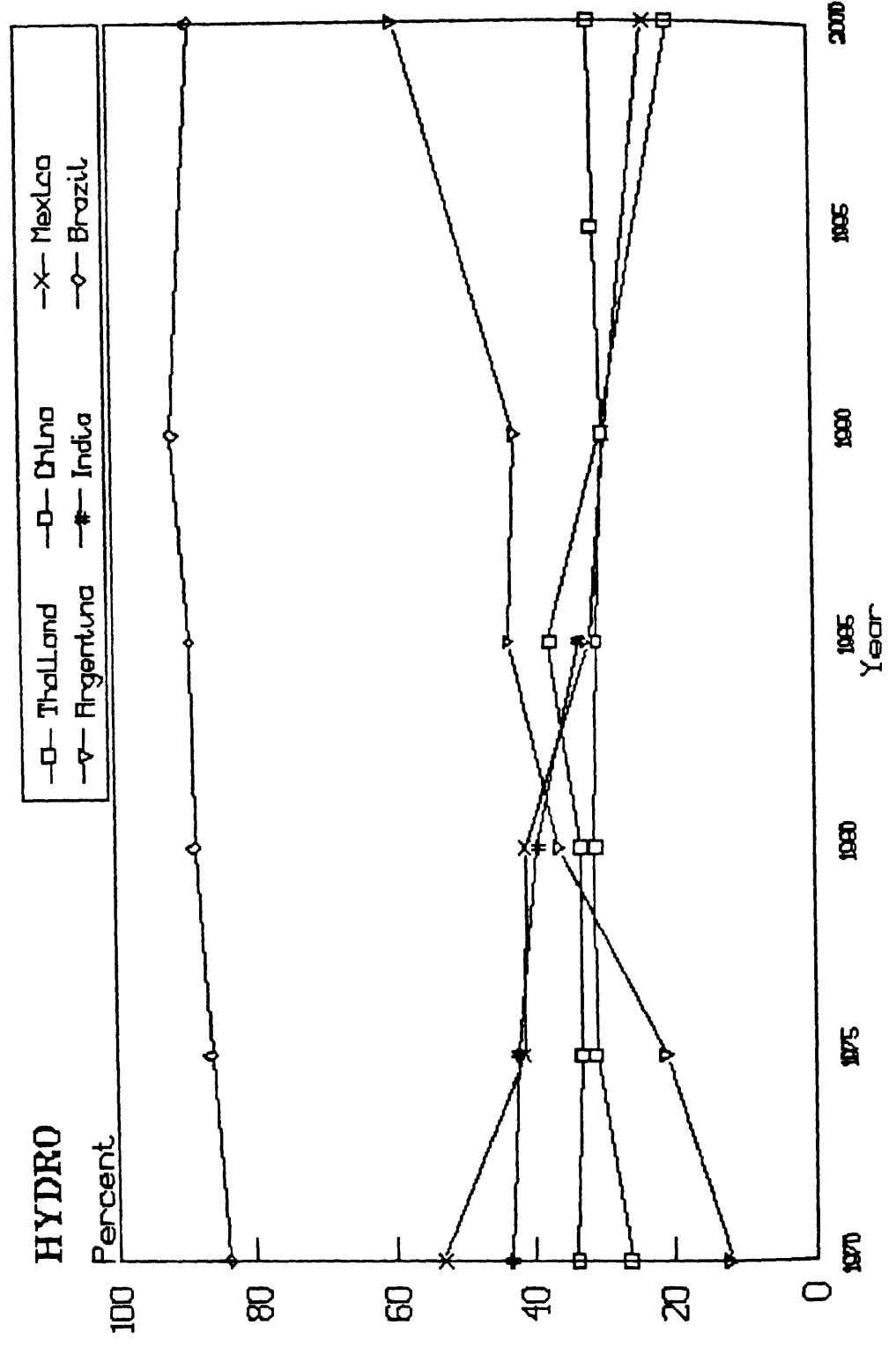


* (not industry, household, transport or agricultural)

Trends for Total Energy Generating Capacity in Sample Countries

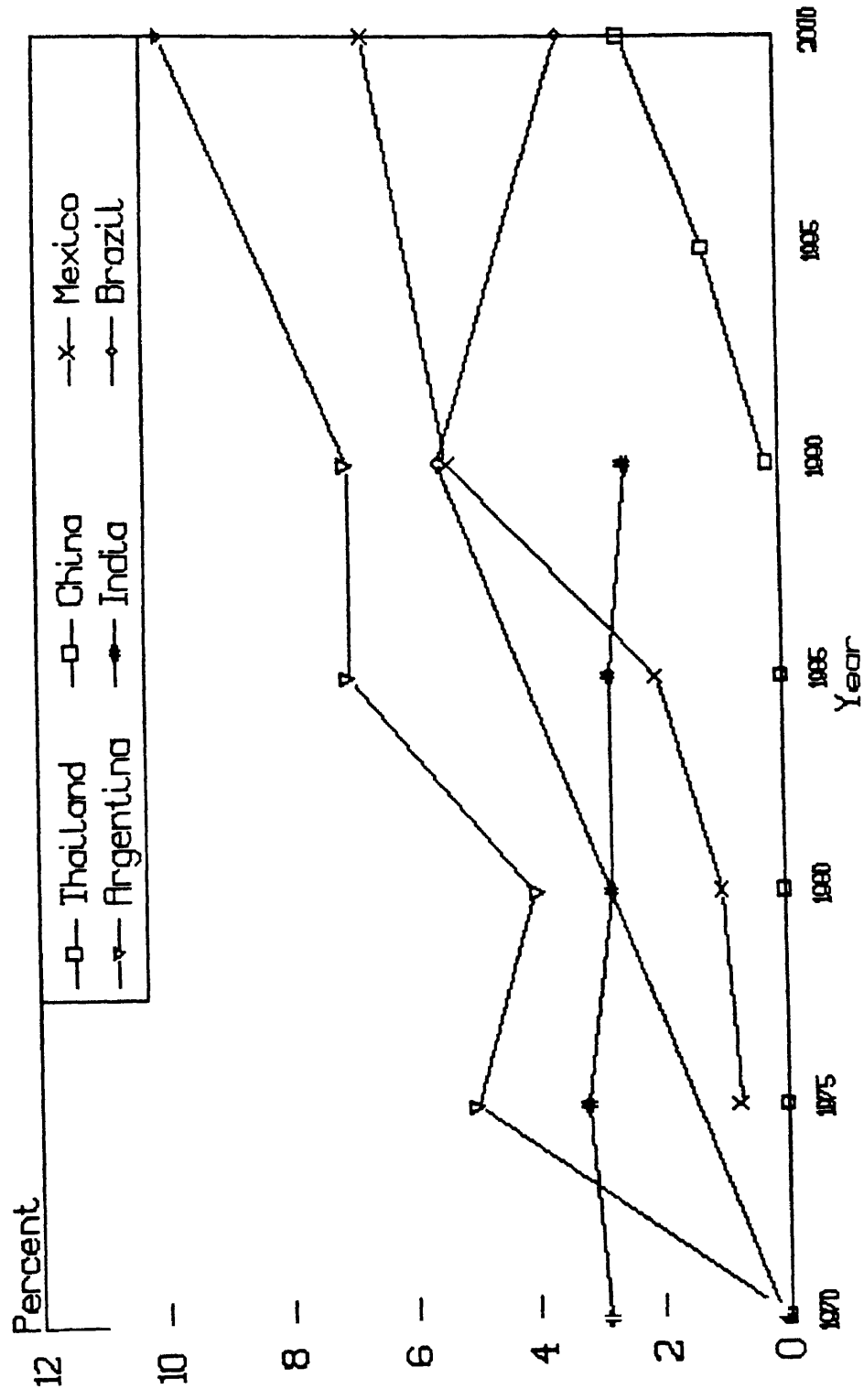


Trends for Energy Generating Capacity in Sample Countries by Source

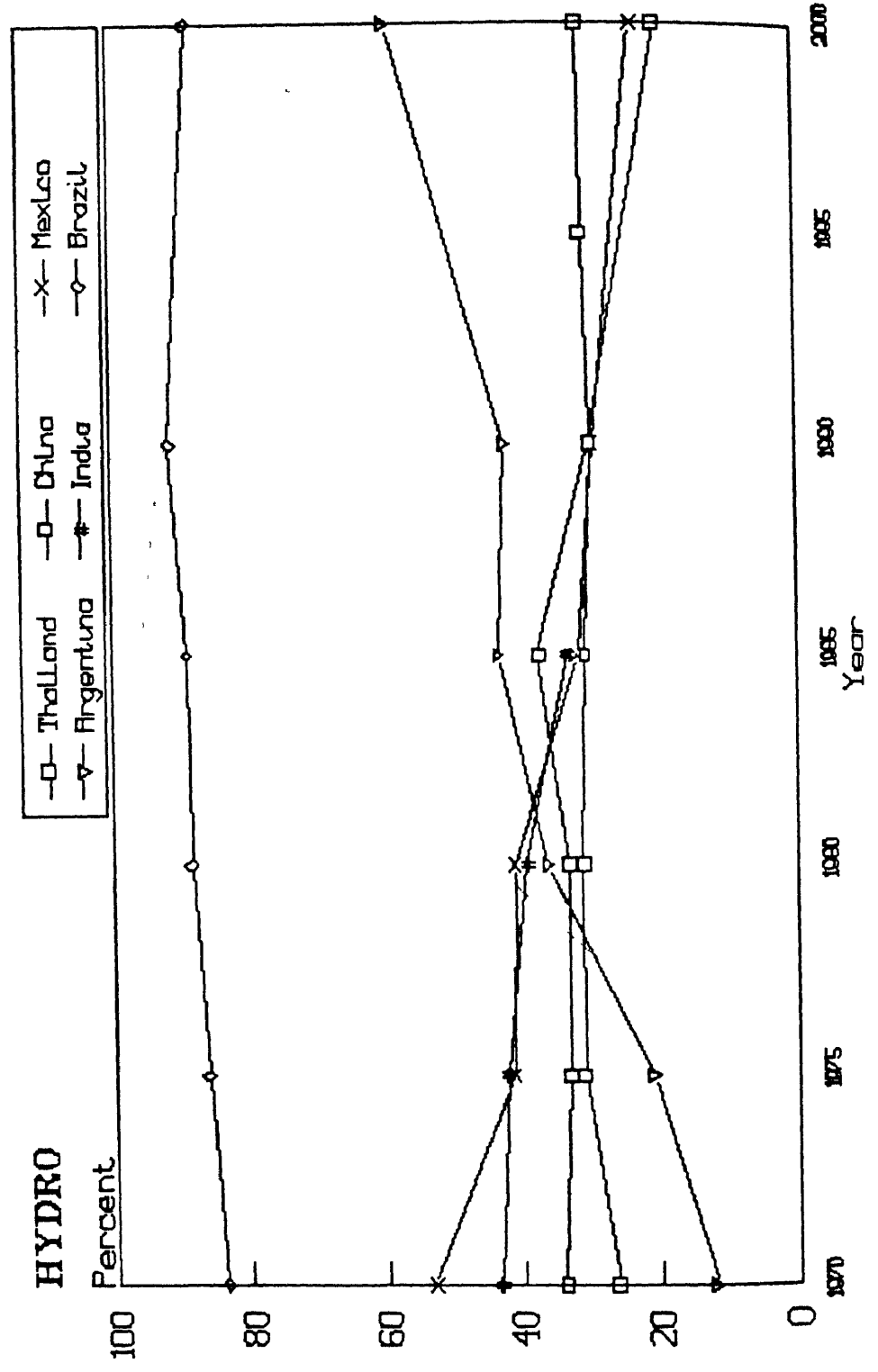


Trends for Energy Generating Capacity in Sample Countries by Source

OTHERS (not hydro or thermal)

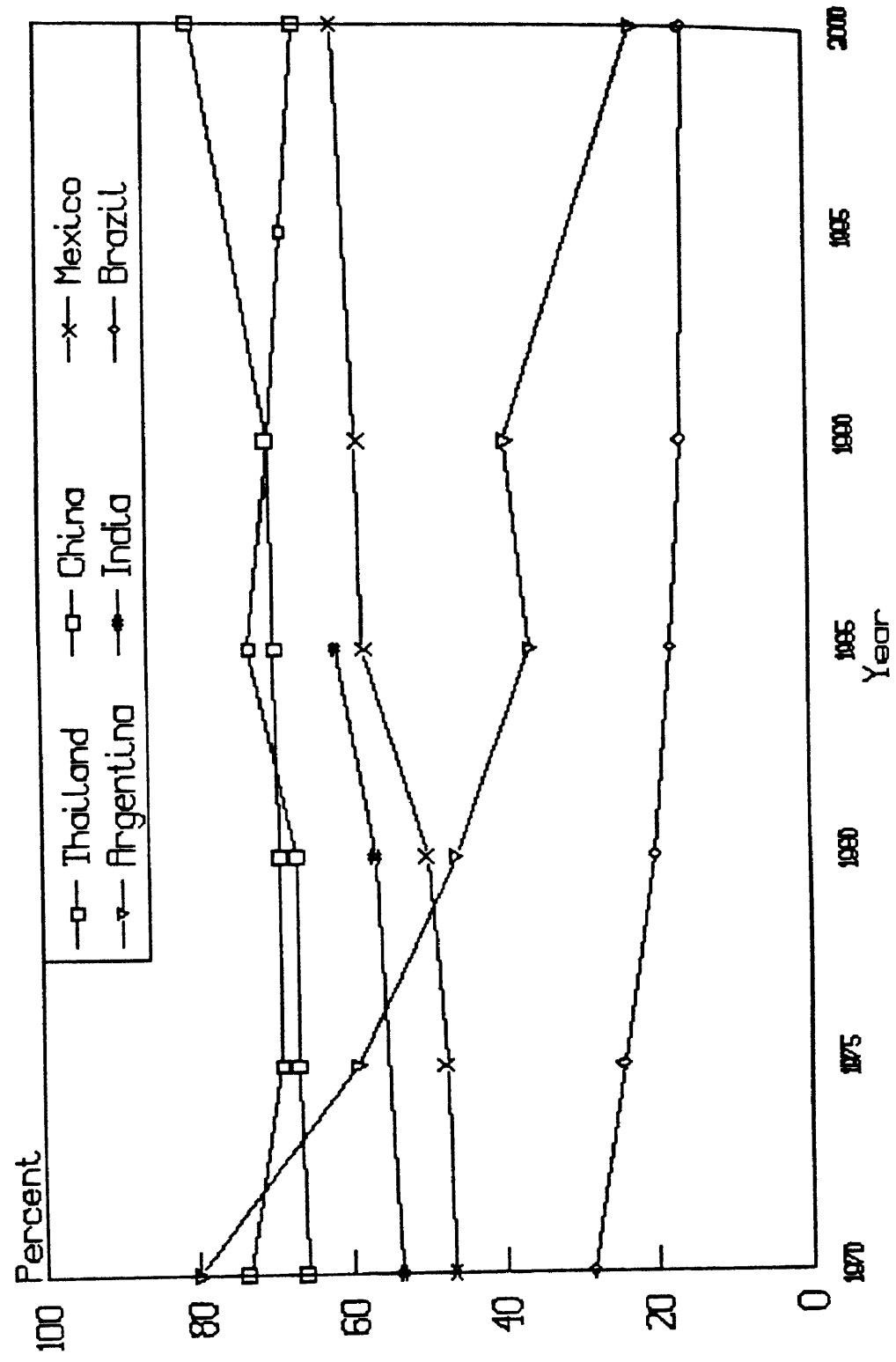


Trends for Energy Generating Capacity in Sample Countries by Source



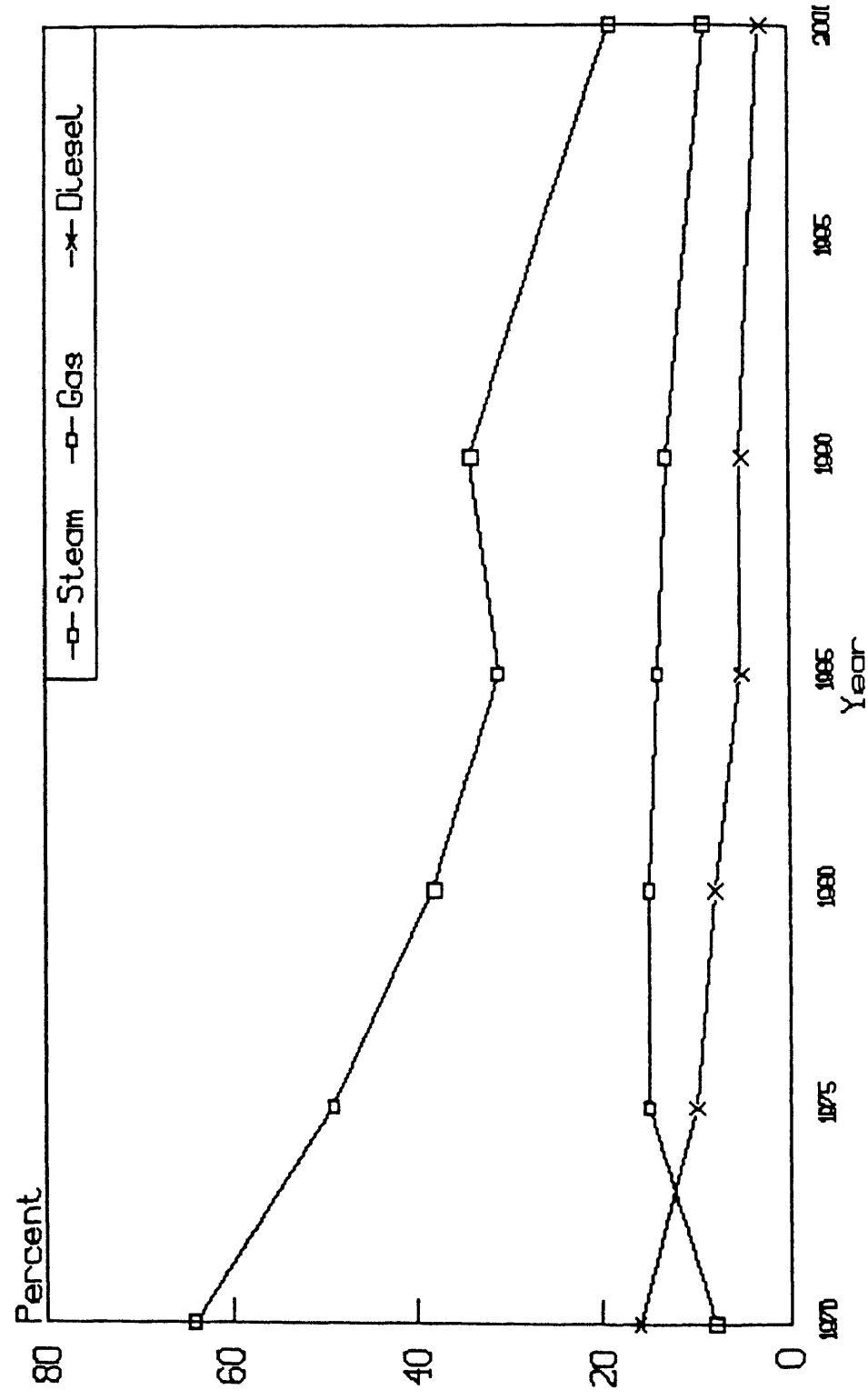
Trends for Energy Generating Capacity in Sample Countries by Source

THERMAL (coal, fuel, gas and diesel)



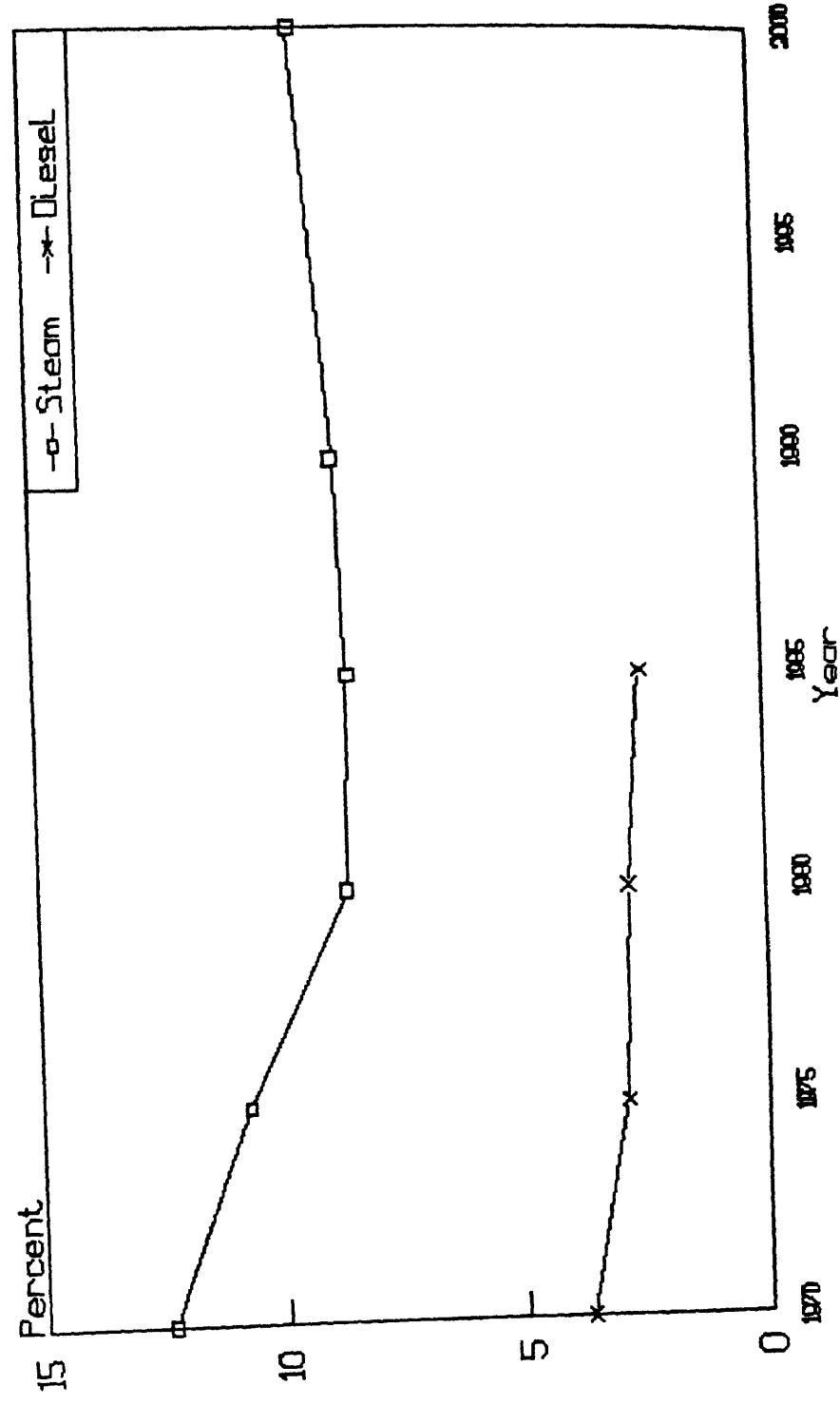
Trends for Energy Generating Capacity in Argentina: Thermal Energy by Source

THERMAL (steam, gas and diesel)



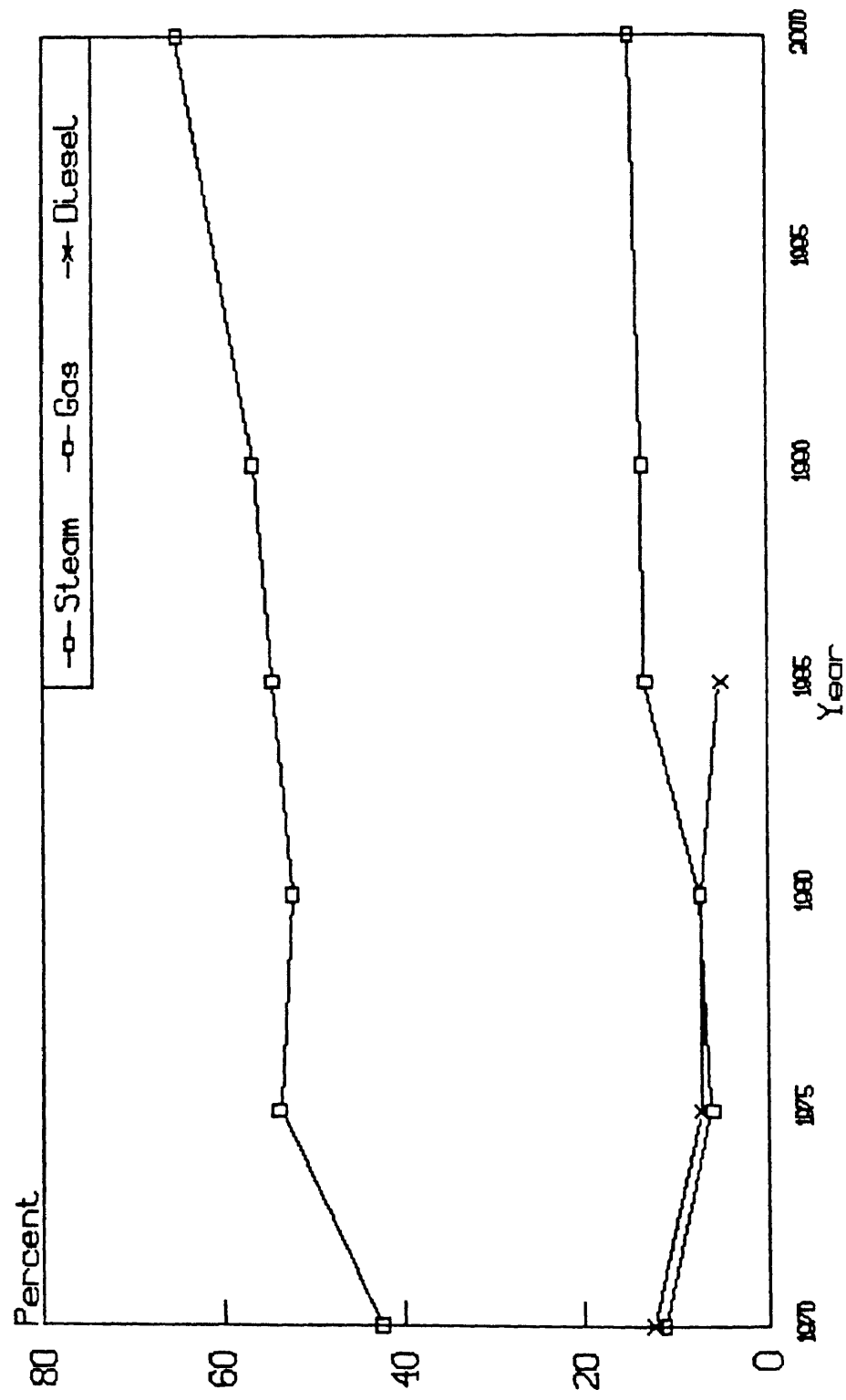
Trends for Energy Generating Capacity in Brazil: Thermal Energy by Source

THERMAL (steam, gas and diesel)



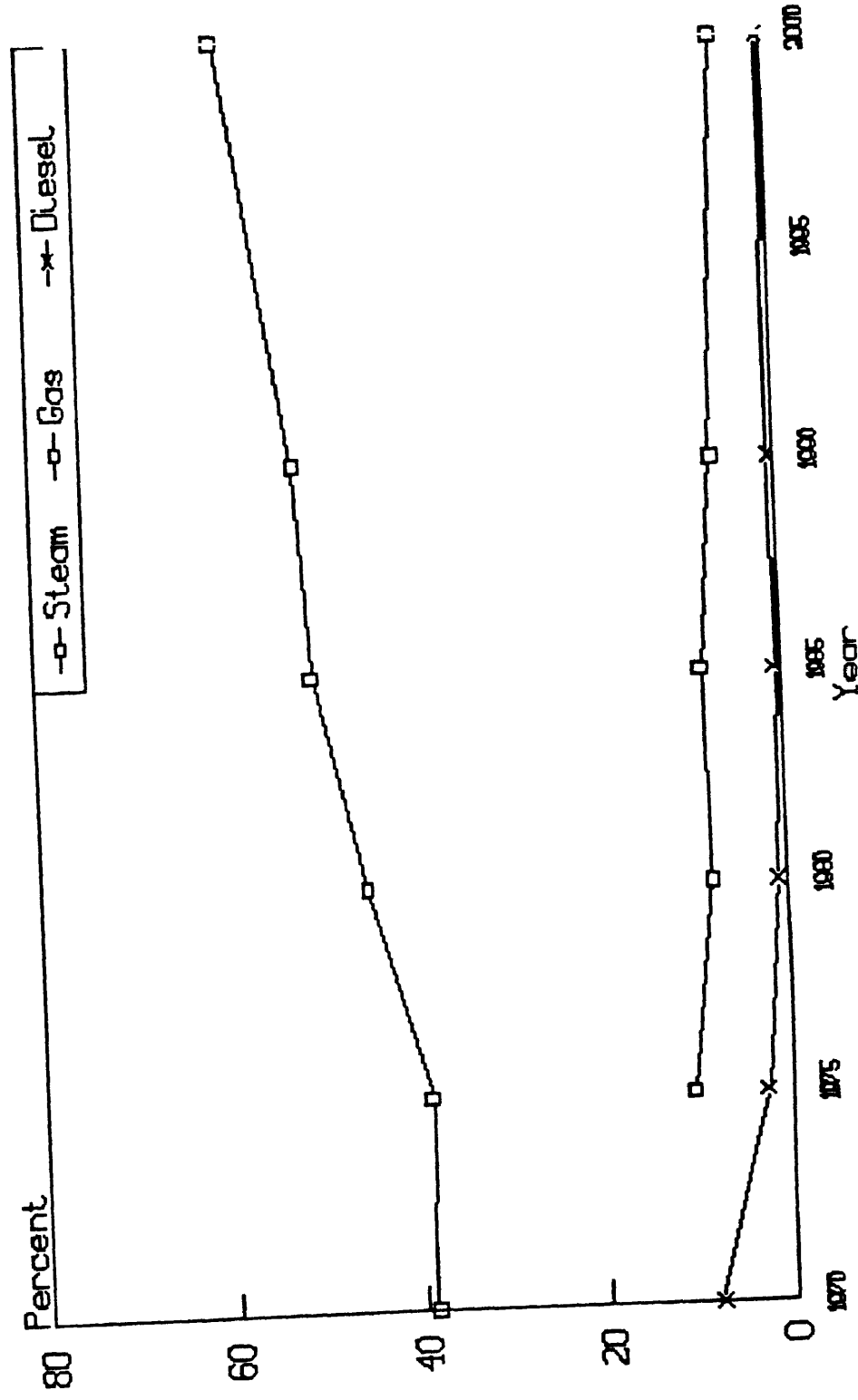
Trends for Energy Generating Capacity in Thailand: Thermal Energy by Source

THERMAL (steam, gas and diesel)



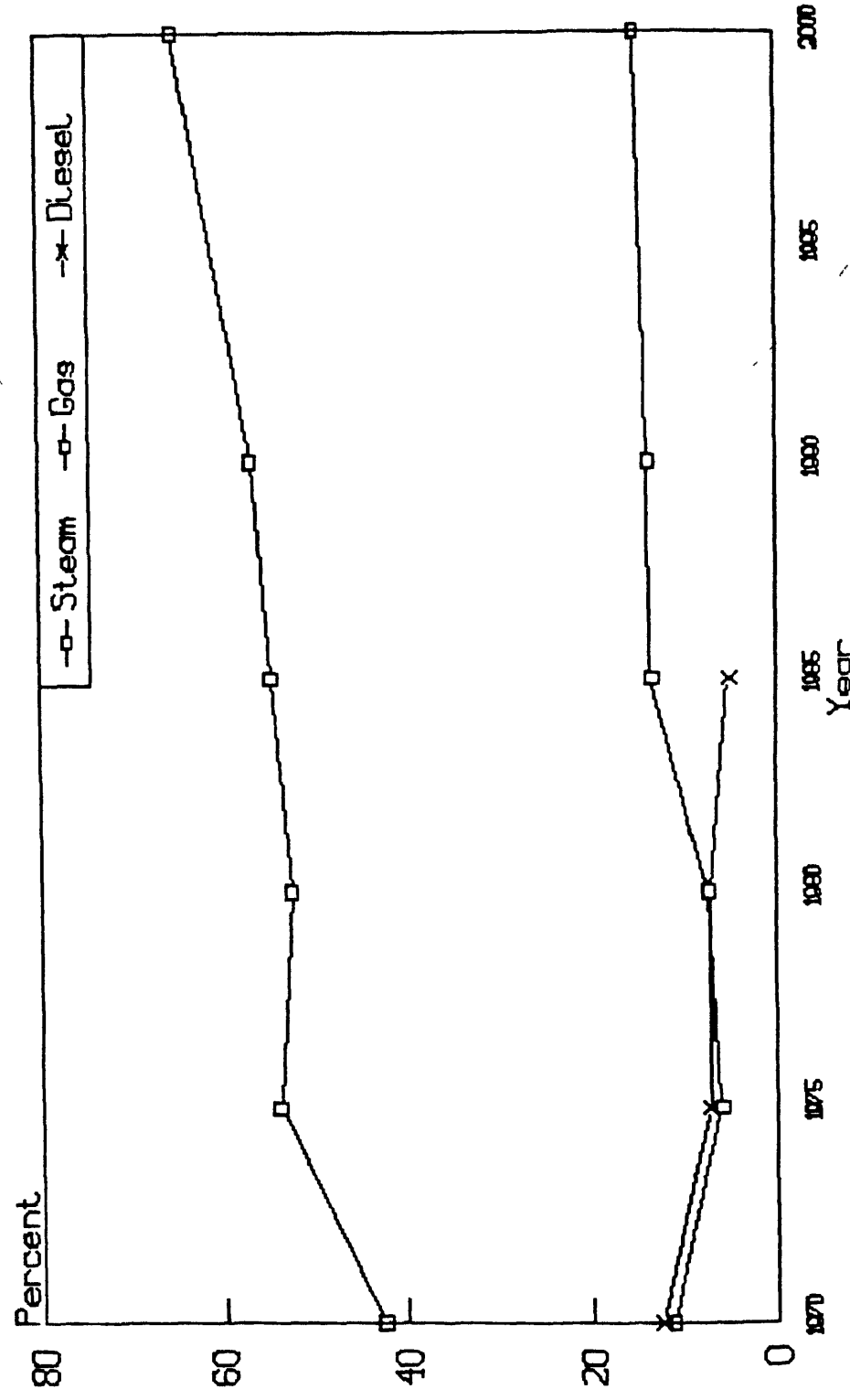
Trends for Energy Generating Capacity in Mexico: Thermal Energy by Source

THERMAL (steam, gas and diesel)



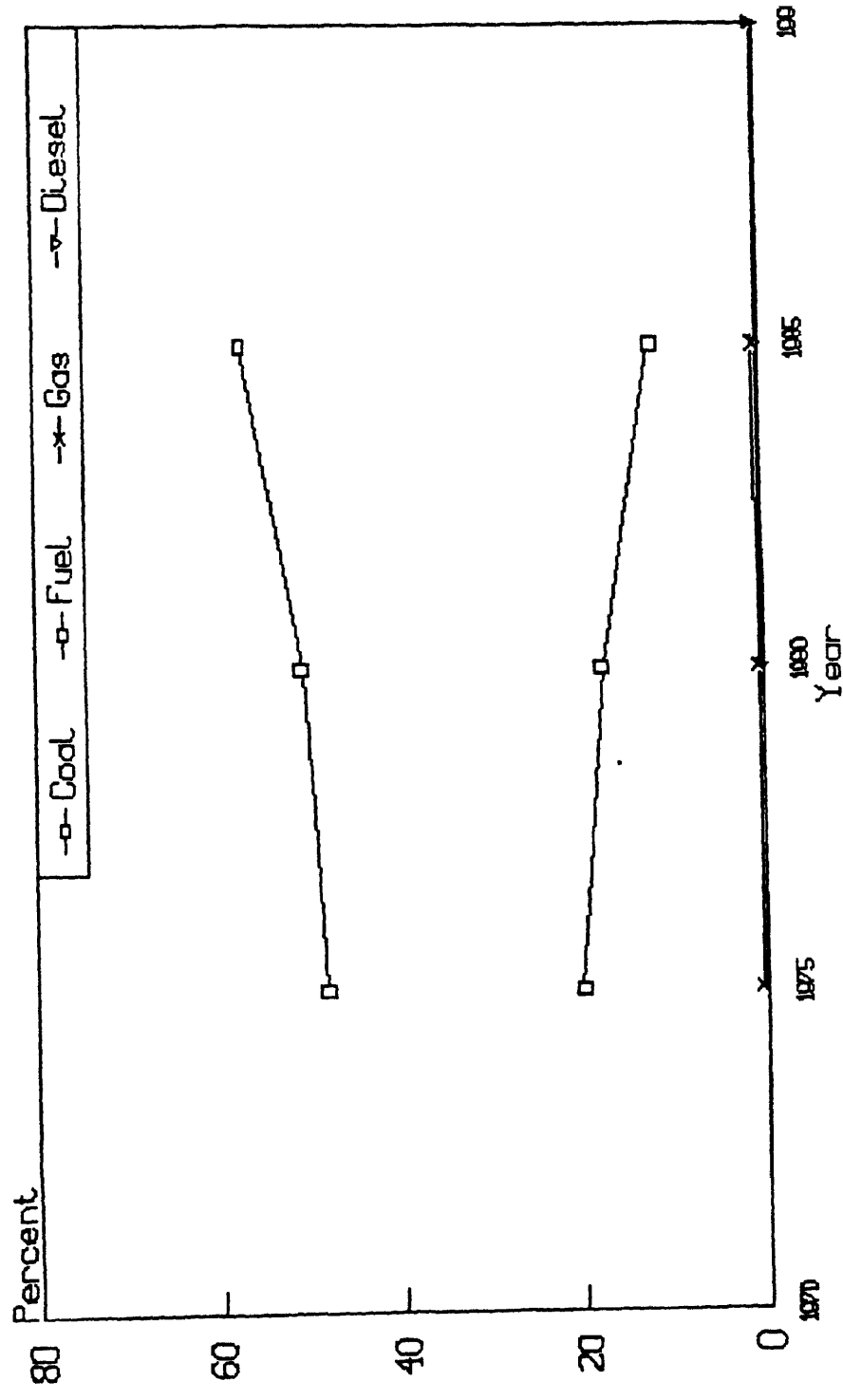
Trends for Energy Generating Capacity in Thailand: Thermal Energy by Source

THERMAL (steam, gas and diesel)



Trends for Energy Generating Capacity in China: Thermal Energy by Source

THERMAL (coal, fuel, gas and diesel)



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